

The impact of climate change and population growth on the Indian Agricultural sector

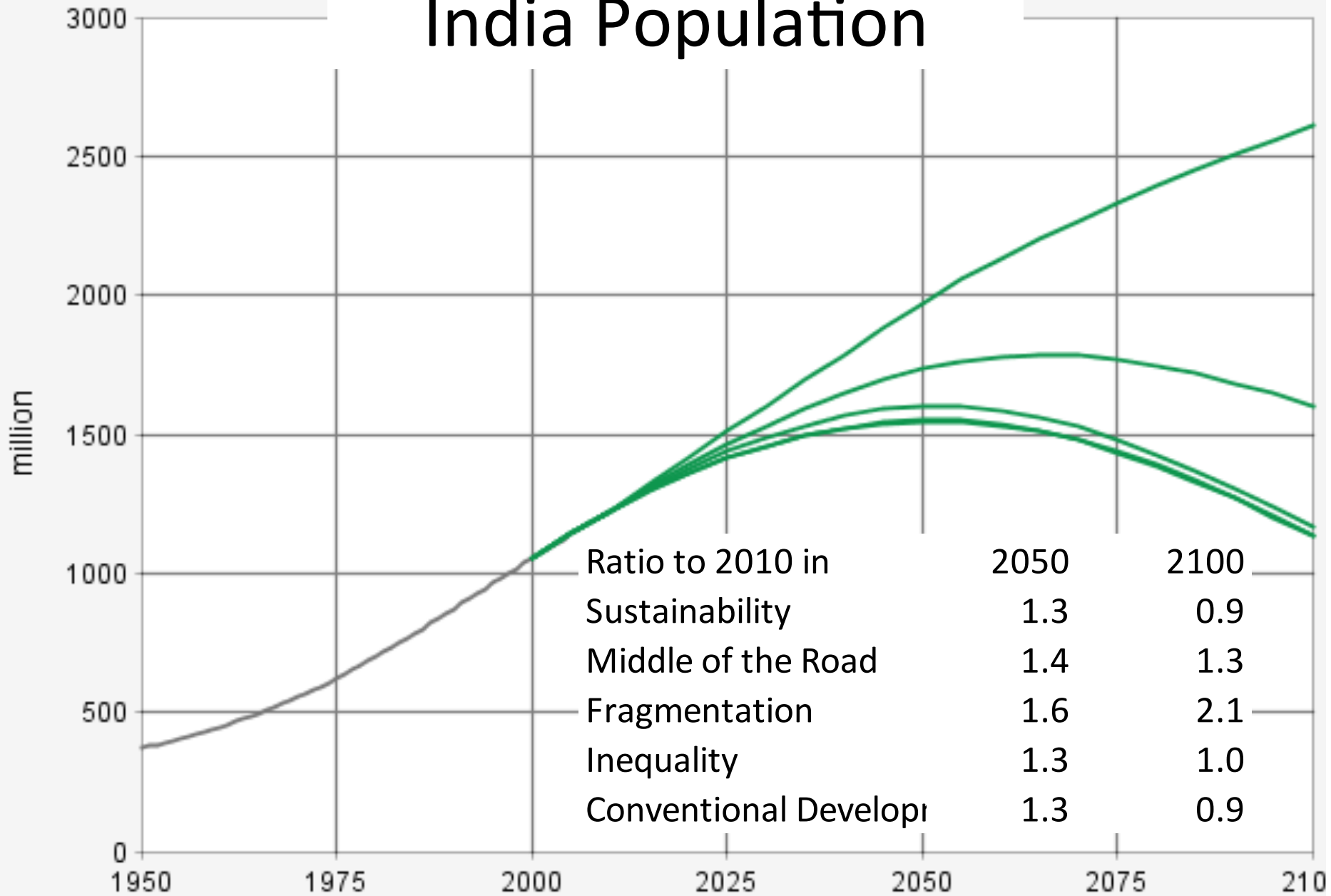
Uwe A. Schneider

Livia Rasche, Roger Cremades, Divya Pandey

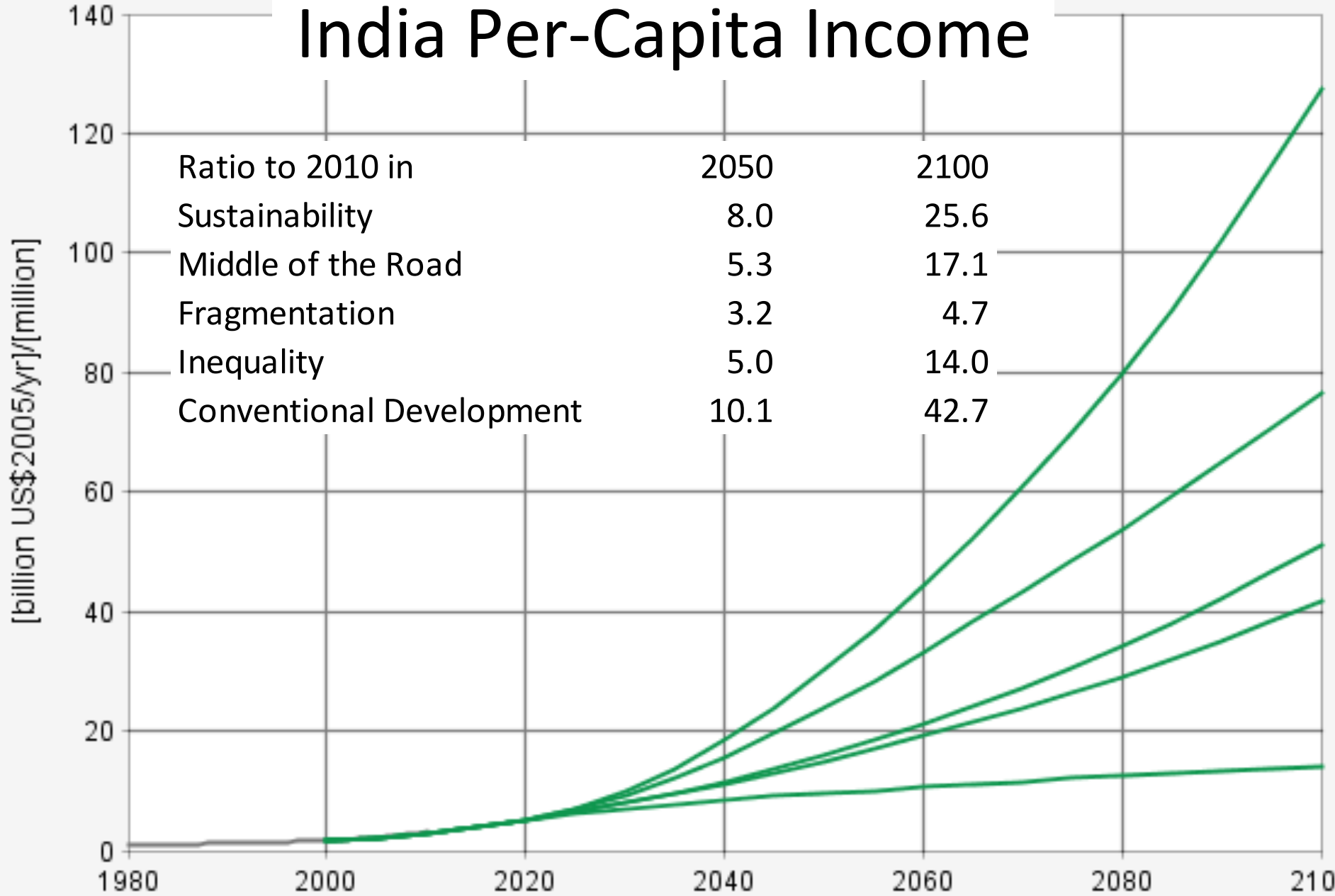
Population development: Shared Socioeconomic Pathways

- SSP1: Sustainability
- SSP2: Middle of the Road
- SSP3: Fragmentation
- SSP4: Inequality
- SSP5: Conventional Development

India Population



India Per-Capita Income



Agricultural Demand Multiplier($\mu=0.3$)

	2050	2100
Sustainability	2.4	2.5
Middle of the Road	2.3	3.1
Fragmentation	2.3	3.4
Inequality	2.1	2.1
Conventional Development	2.5	2.9

Agricultural Demand Multiplier ($\mu=0.8$)

	2050	2100
Sustainability	6.7	12.5
Middle of the Road	5.4	12.7
Fragmentation	4.1	7.4
Inequality	4.7	7.9
Conventional Development	8.0	18.7

Data/Scenarios on
Soil, Climate,
Management

(Statistics, Remote Sensing)

Agricultural Sector Analysis

Engineering

(Adaptation, Mitigation)

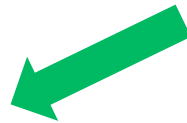
**Biogeochemical
crop/tree models**

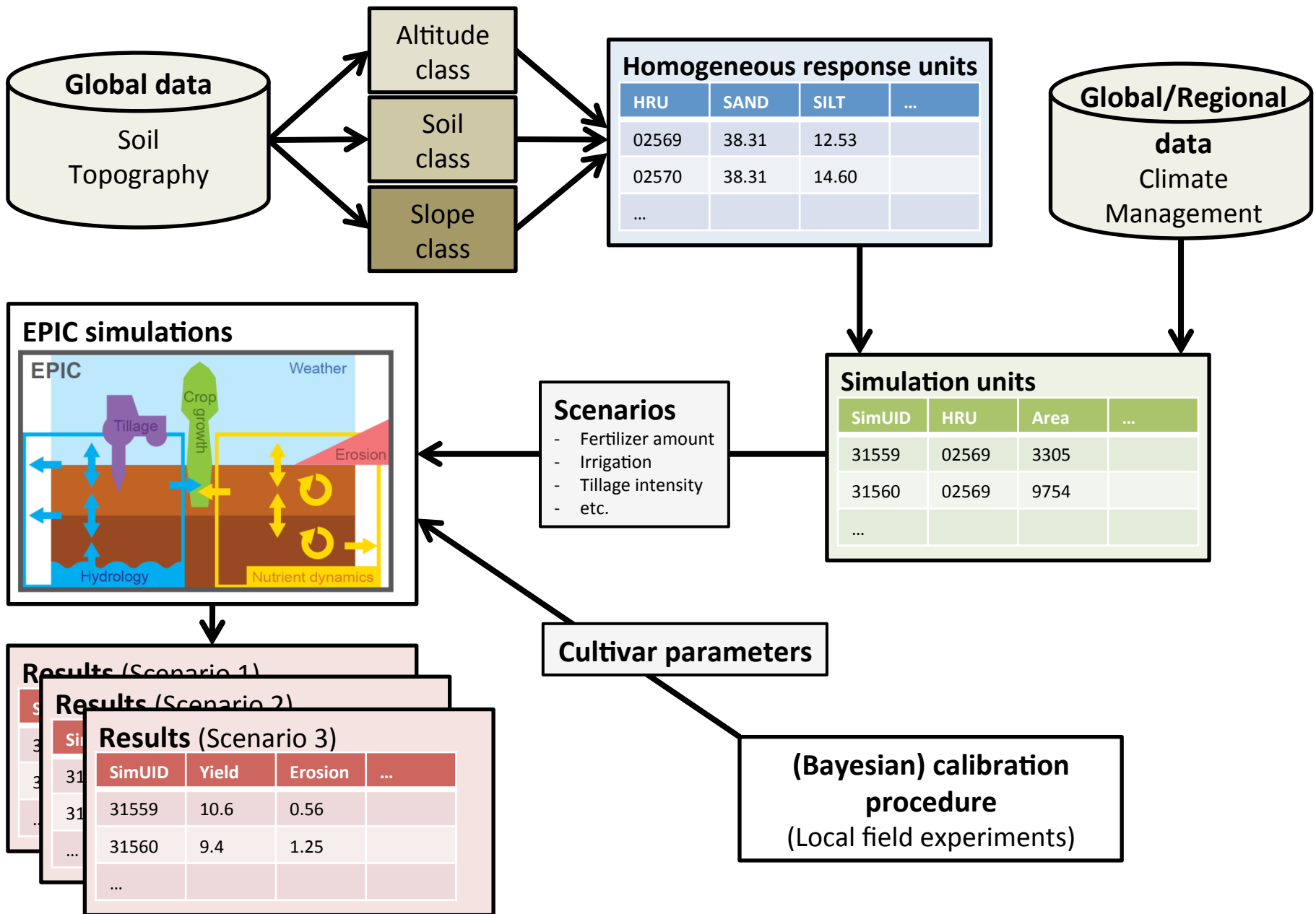
Ecosystem data

Agricultural Sector
Model

Ecosystem
Models

Policy and development scenarios





Crop model output

dry Matter Yield in (t/ha)
dry matter forage yield in t/ha
total biomass in t/ha
N,P,C in crop yield in kg/ha

Actual evapotranspiration in
mm

Runoff in mm

Subsurface flow in mm

Percolation in mm

N,P fertilizer in kg/ha
irrigation in mm

n fixation in kg/ha

nitrification kg/ha

air volatilization in kg/ha

denitrification in kg/ha

org. N in sediment in kg/ha

N in runoff in kg/ha

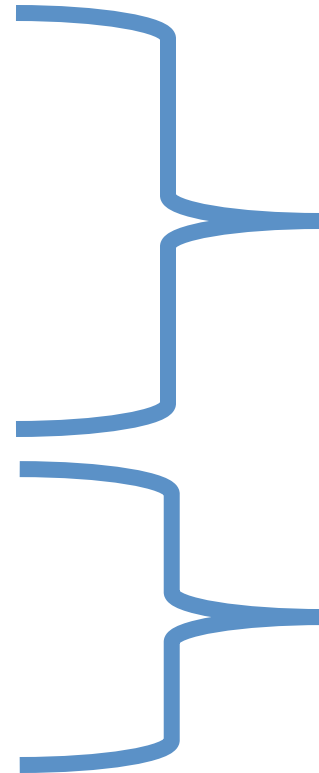
N in subsurface flow in kg/ha

N in percolation in kg/ha

topsoil SOC in t/ha

Indian Crop Simulations

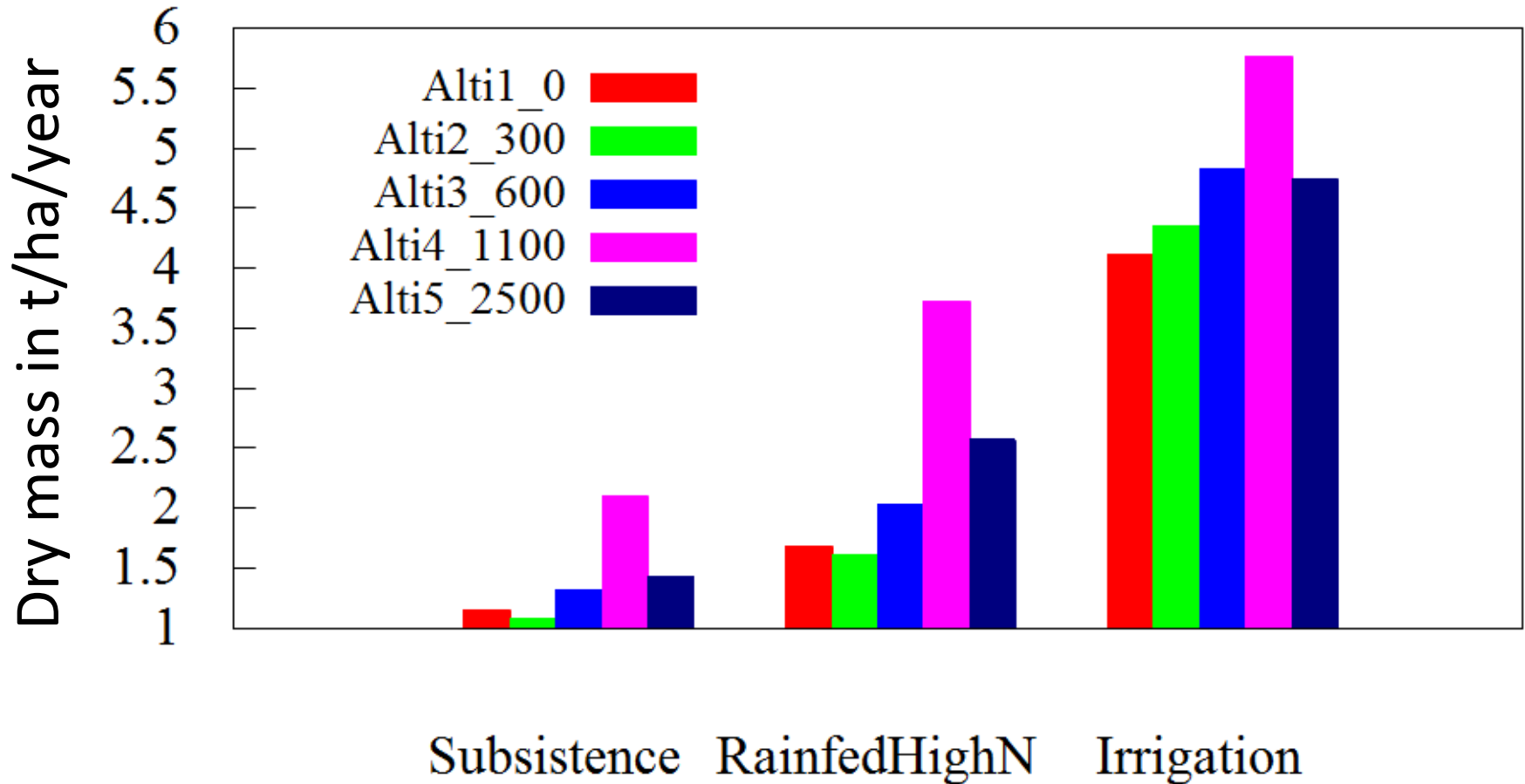
- 30x30 km Grid
- 5 soil texture classes
- 5 slope classes
- 5 altitude classes
- >20 crops
- 4 irrigation systems
- 3 nitrogen intensities
- **Climate scenarios**



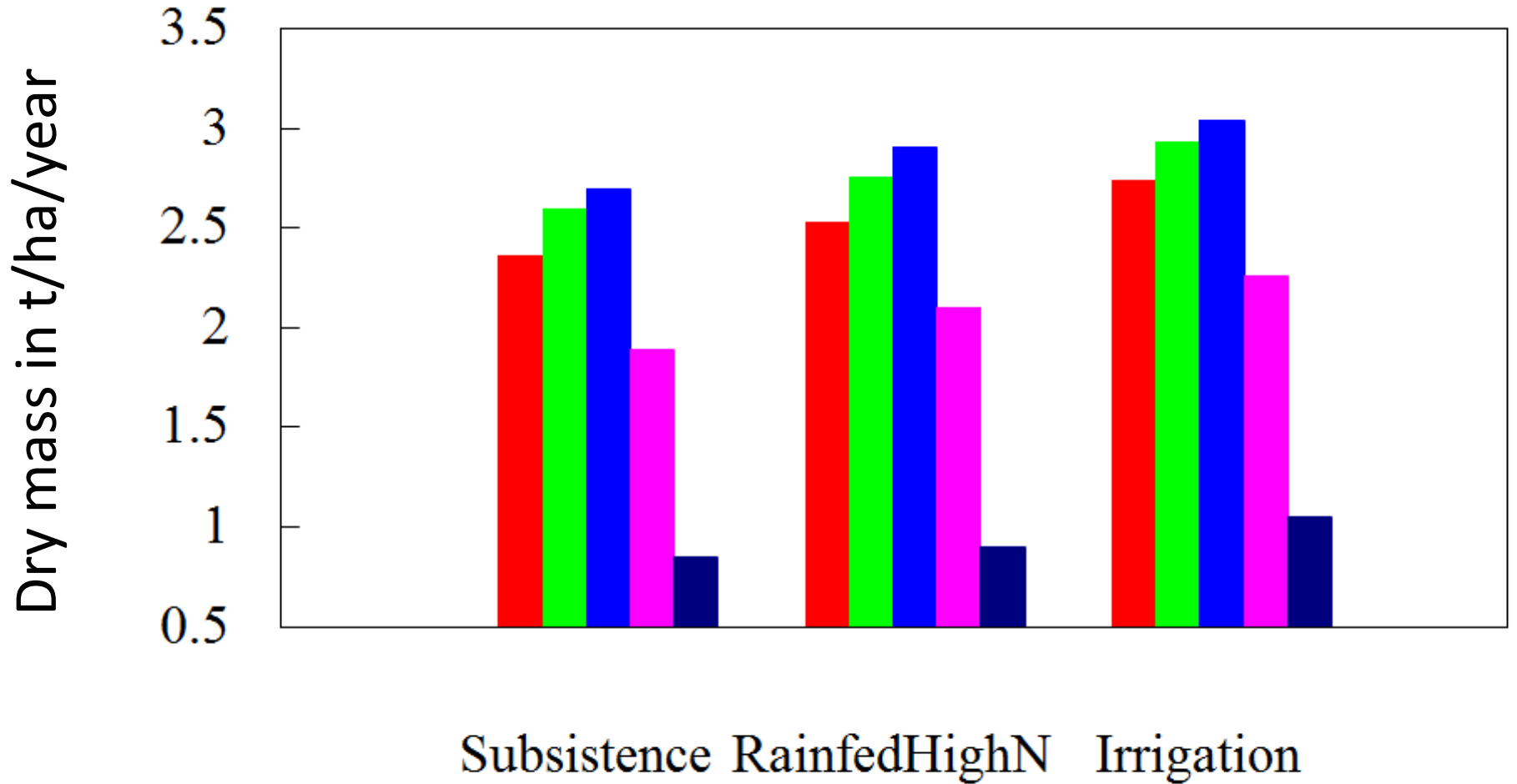
Land

Management

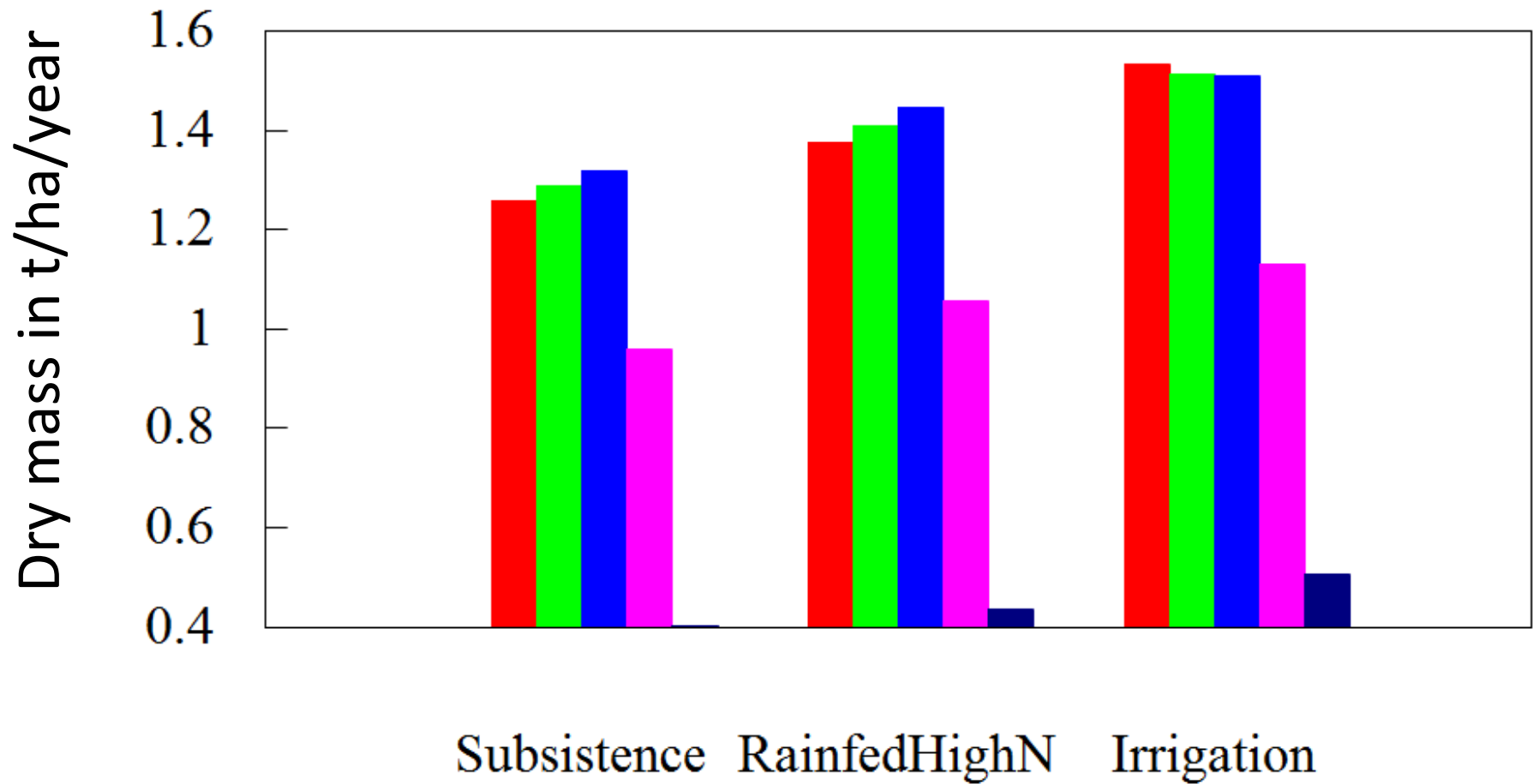
2005 Wheat Yields India



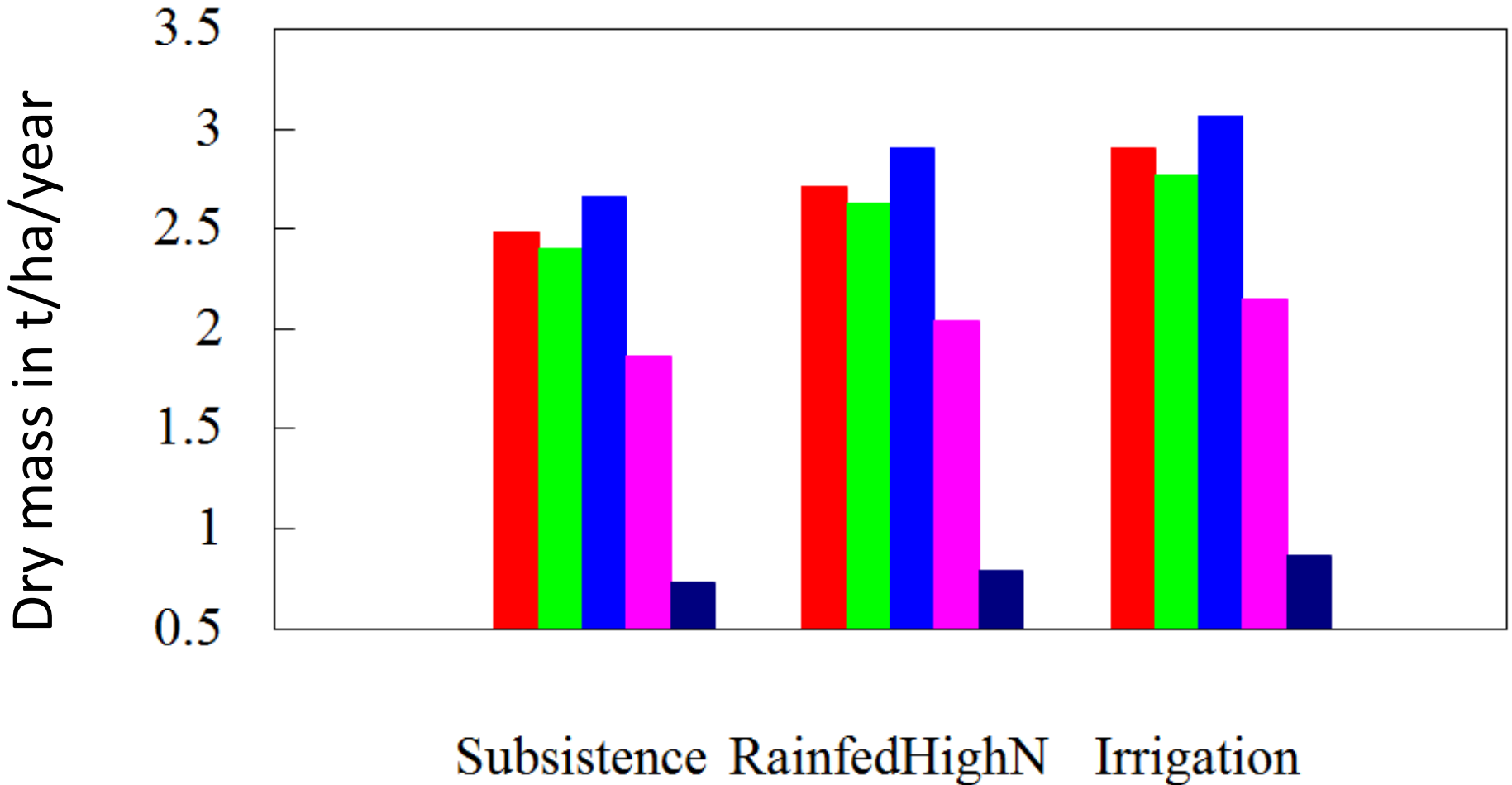
2005 Rice Yields India



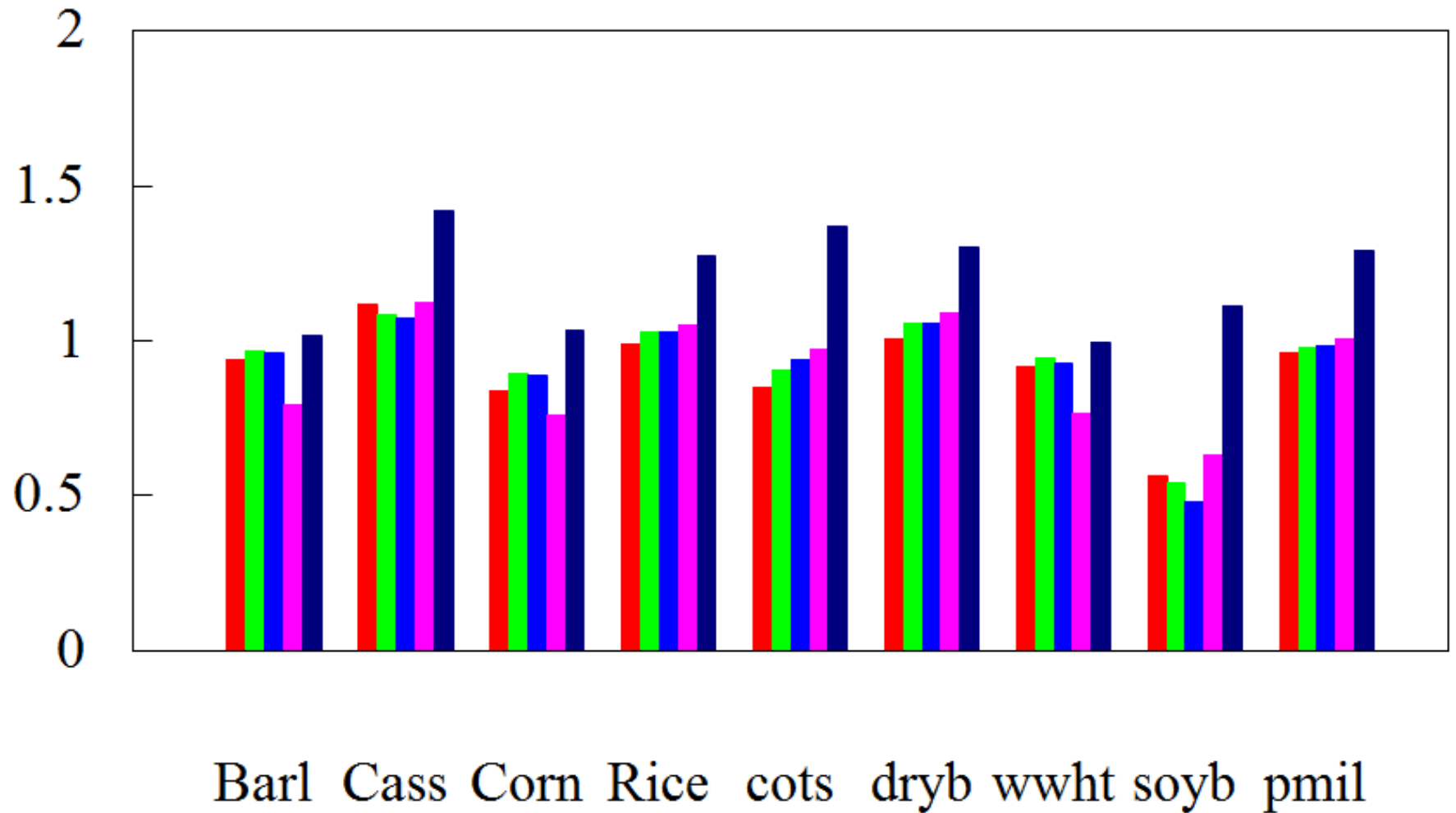
2005 Dry Bean Yields India



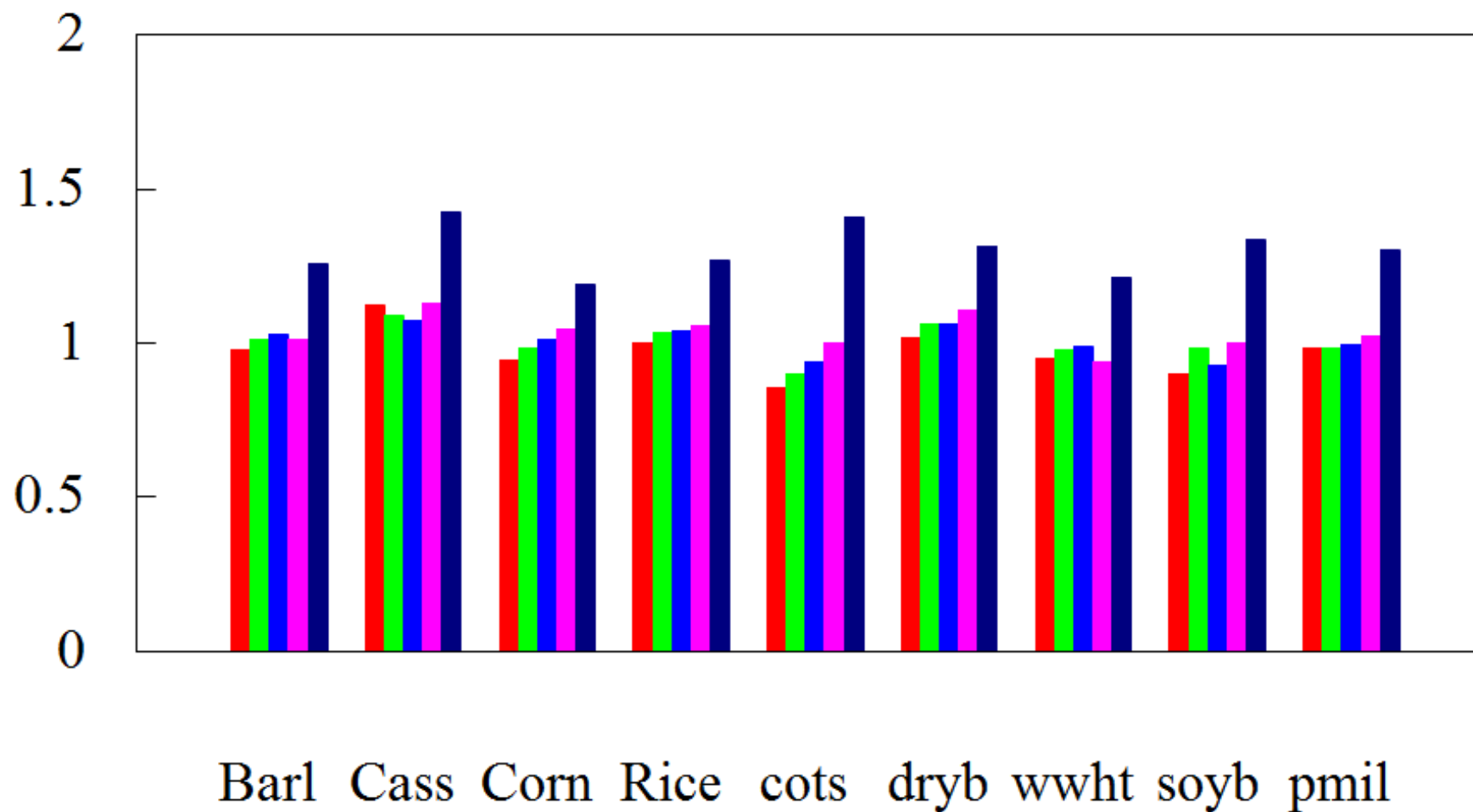
2005 Cassava Yields India



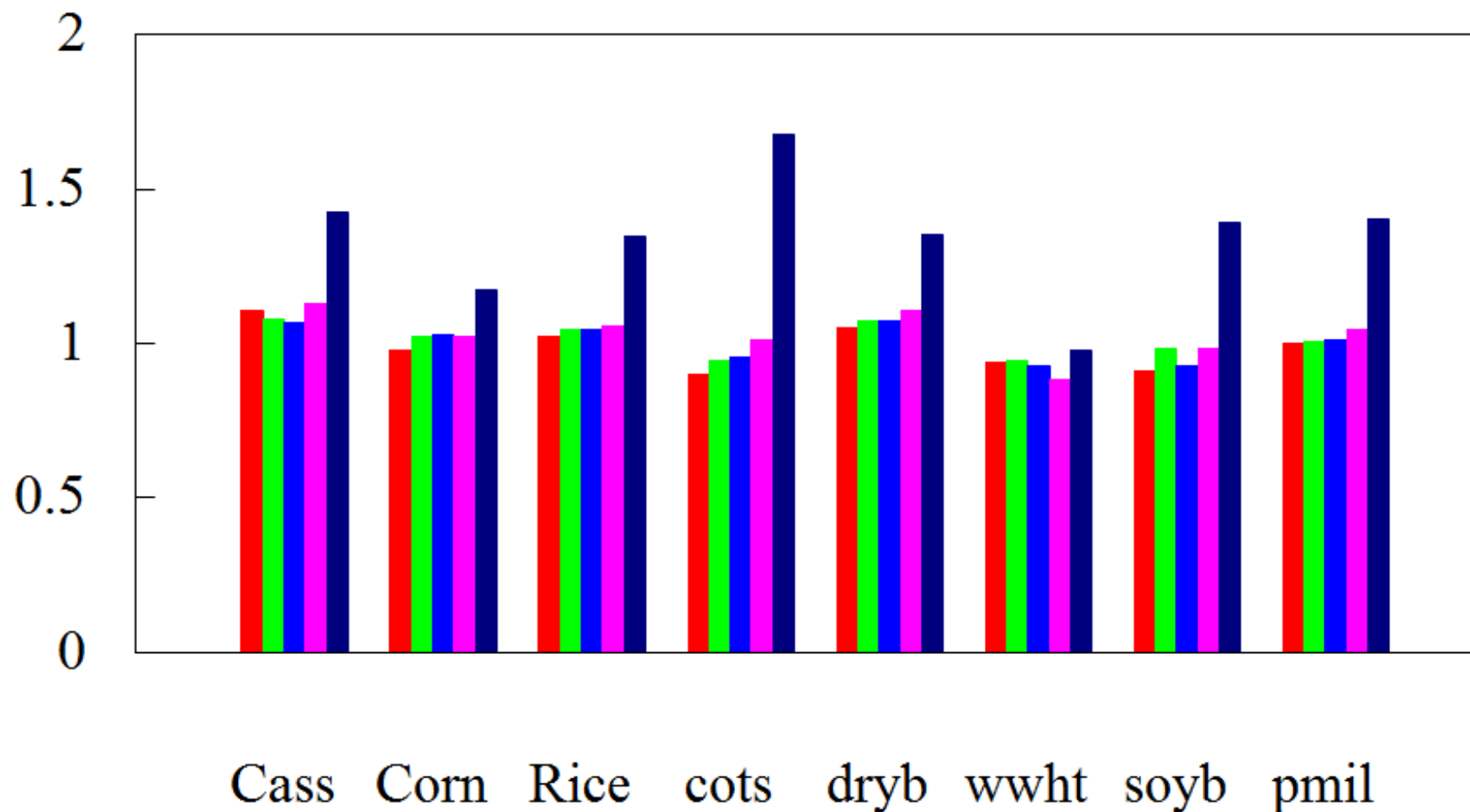
RCP 8.5 climate - 2030/2005 yield ratio Subsistence farming



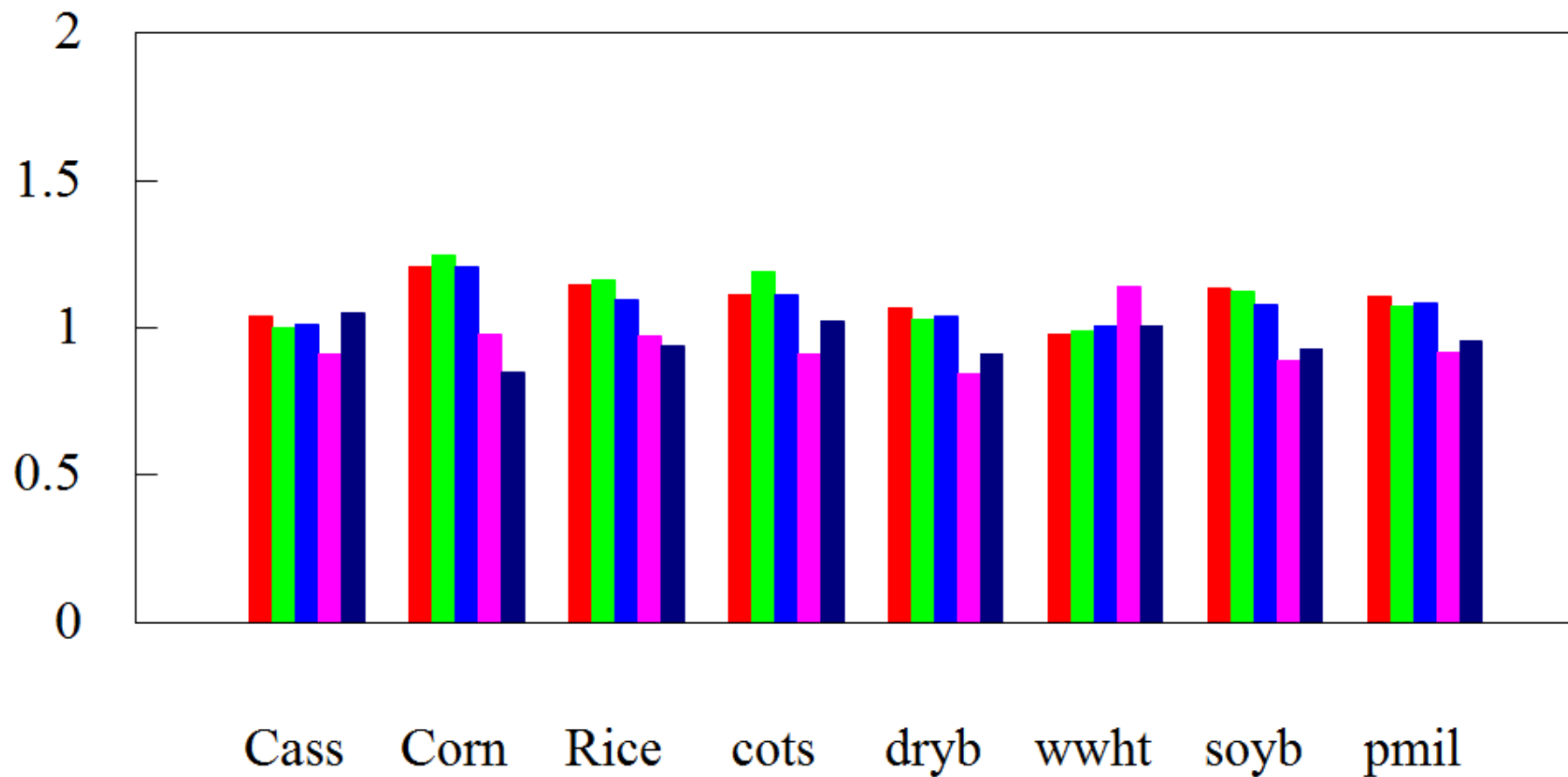
RCP 8.5 climate - 2030/2005 yield ratio High N without irrigation



RCP 8.5 climate - 2030/2005 yield ratio High N with irrigation



RCP 8.5 climate - 2030/2005 irrigation water ratio



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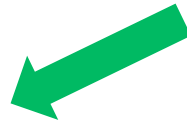
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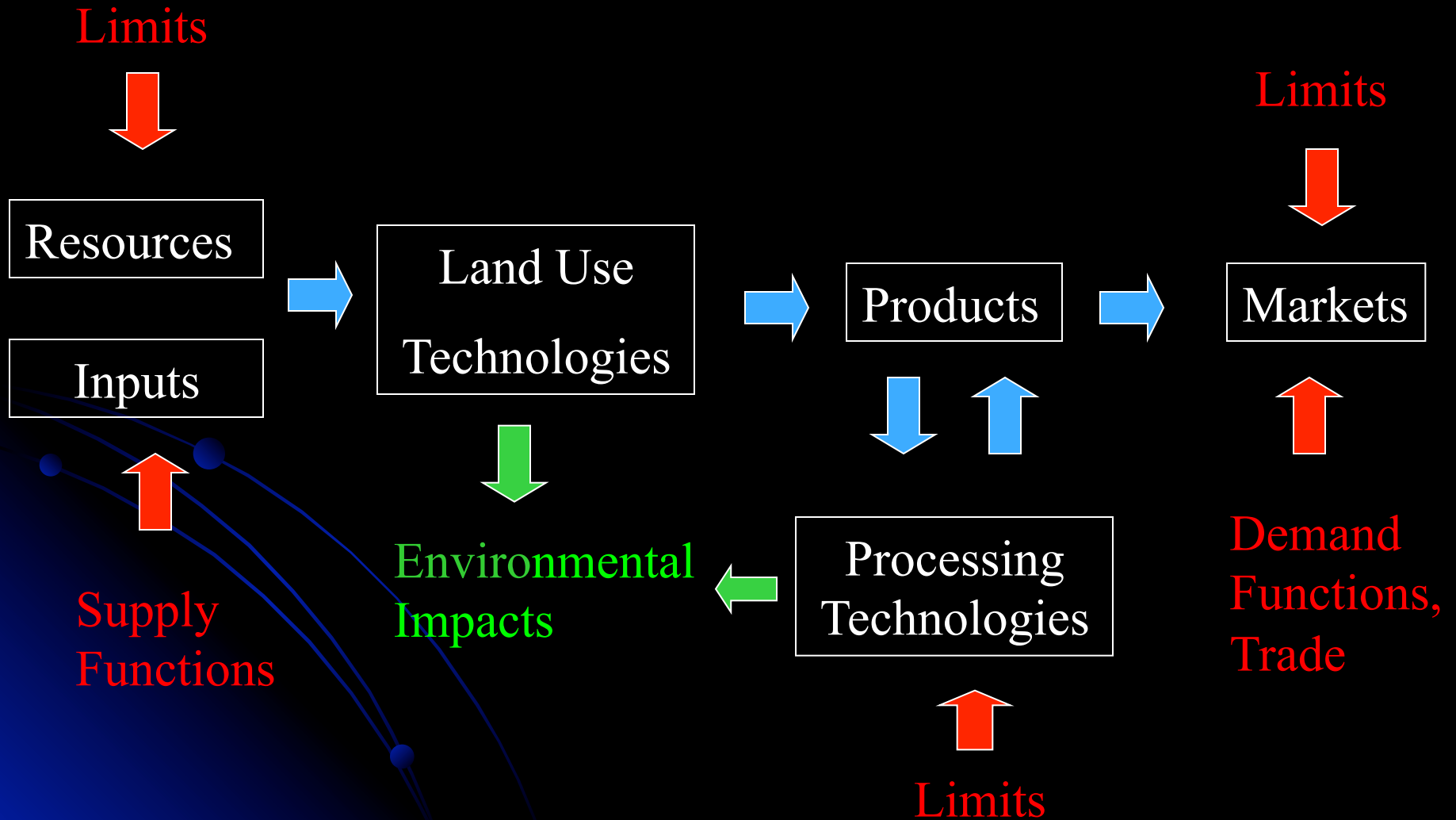
**Agricultural Sector
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Agricultural Sector Model

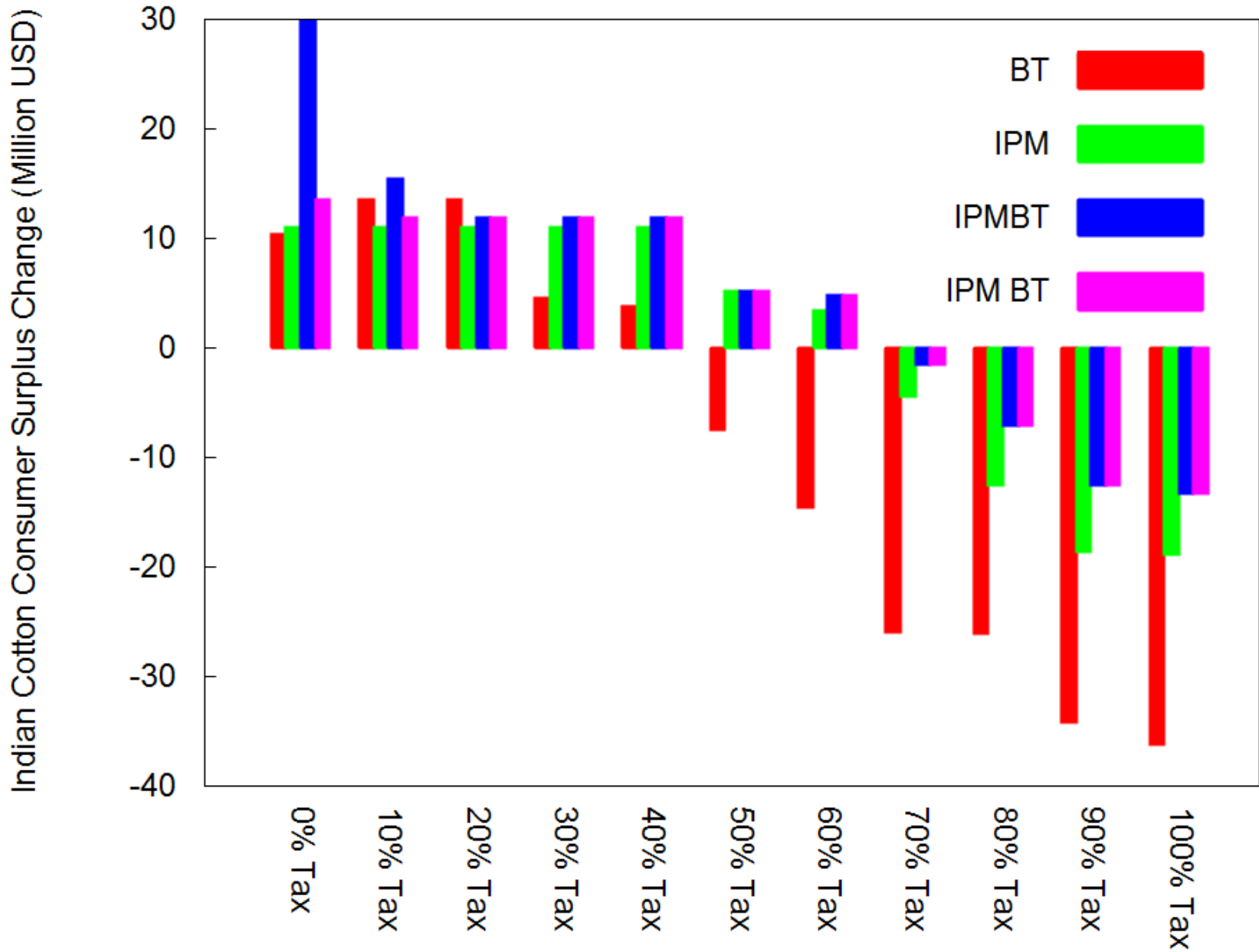


Mathematical Structure

$$\text{Max Global Welfare} = \sum_t \left(\partial_t \cdot \left(\begin{array}{l} \sum_{r,y} \text{Consumer Surplus}_{t,r,y} \\ + \sum_{r,u} \text{Resource Surplus}_{t,r,u} \\ - \sum_{r,j} \text{Transformation Cost}_{t,r,j} \end{array} \right) \right) + \sum_{r,f} \text{Terminal Values of Forests}_{r,f}$$

- s.t.
- Resource limitations
 - Technical efficiencies
 - Political constraints
 - Intertemporal relationships

Internalization of agricultural pesticides



Source: Rasche et al. 2014 submitted

Summary

- Socioeconomic development will strongly increase demand
- Climate change will increase challenges on supply side
- Environmental/sustainability concerns will increase supply pressure (short run)
- Adaptation will be key

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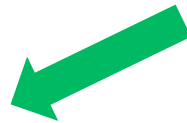
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Thank you