Rainfed Agriculture, Climate Change & Food security
Prospects, Opportunities and Risks
Mitigation and Adaptation

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IIASA, Laxenburg, Austria
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Climate Change, Water and Food Security
26-28th 2008
FAO, Rome

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Integrated Agroecology-Socioeconomy Spatial Methodology and Policy Analysis

- Climate Change and Variability: Agro-ecology
- Arable Land & Water Resources: Productivity & Sustainability
- Food Production and Trade: Food Security
- Rural Population: Agriculture and Rural Livelihoods
- Rainfed Agriculture & Climate Change Mitigation
- Rainfed Agriculture & Climate Change Adaptation

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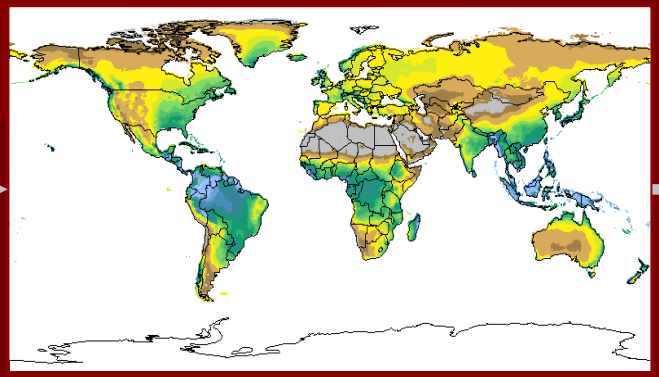
Agroecology-Socioeconomic Modeling



3

2 Climate model

1 GGI scenario

Climate impact response relations 4

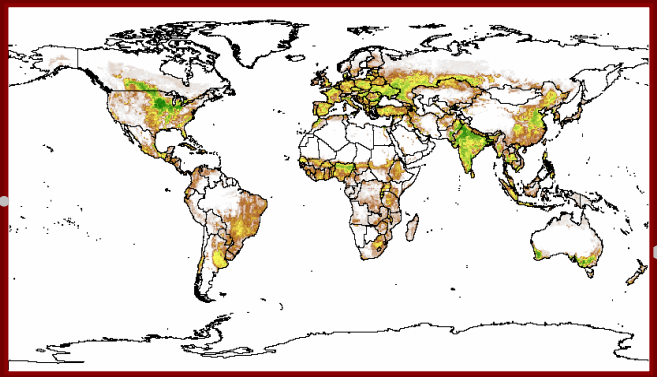
Production

Demand

Trade

Global Food System

World Market 5



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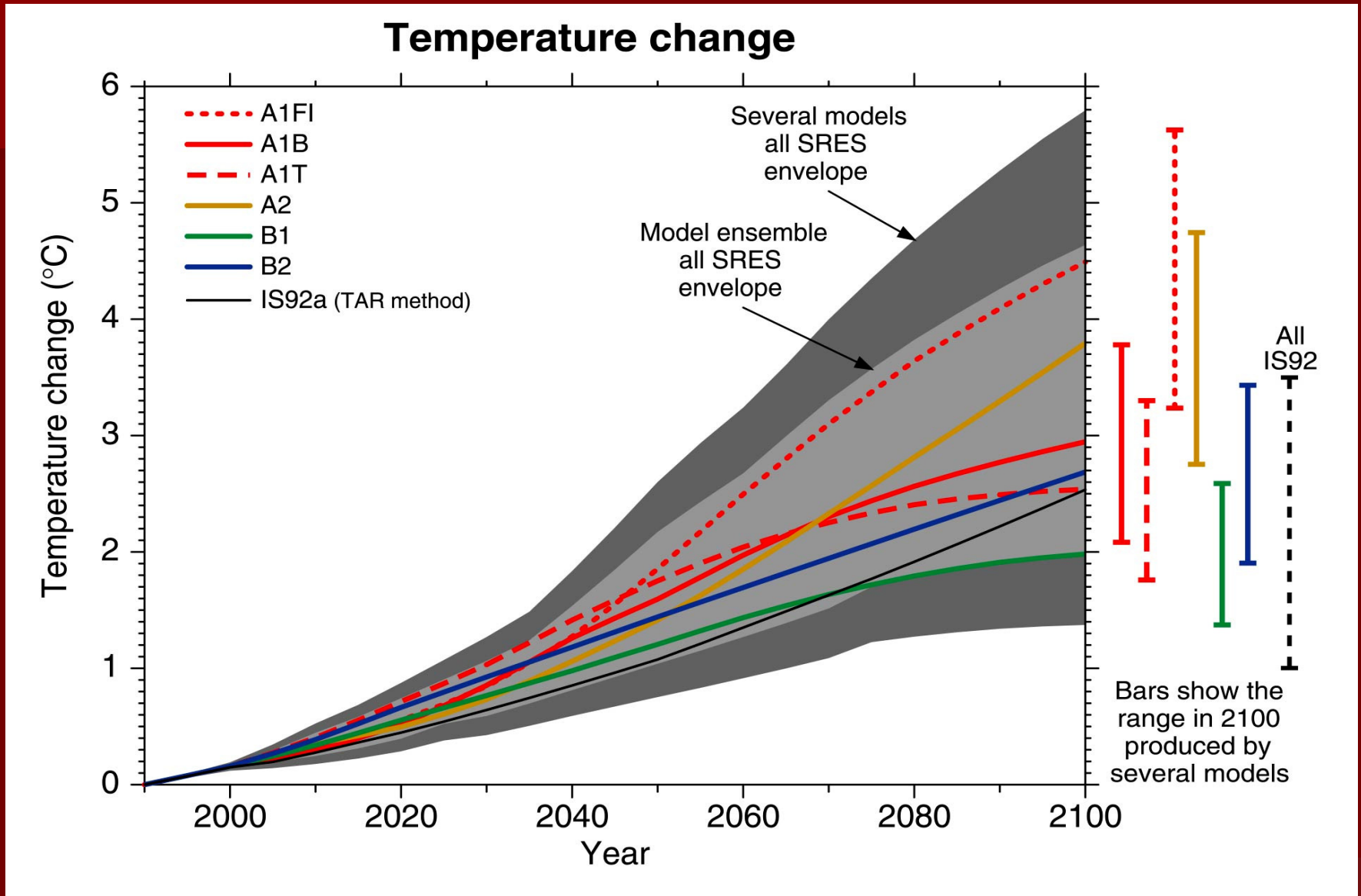
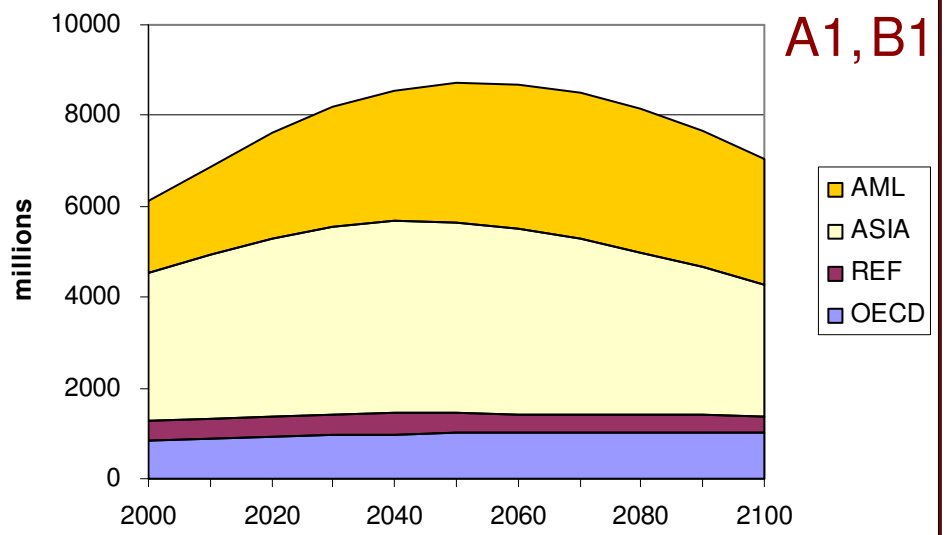
IPCC SRES Scenarios



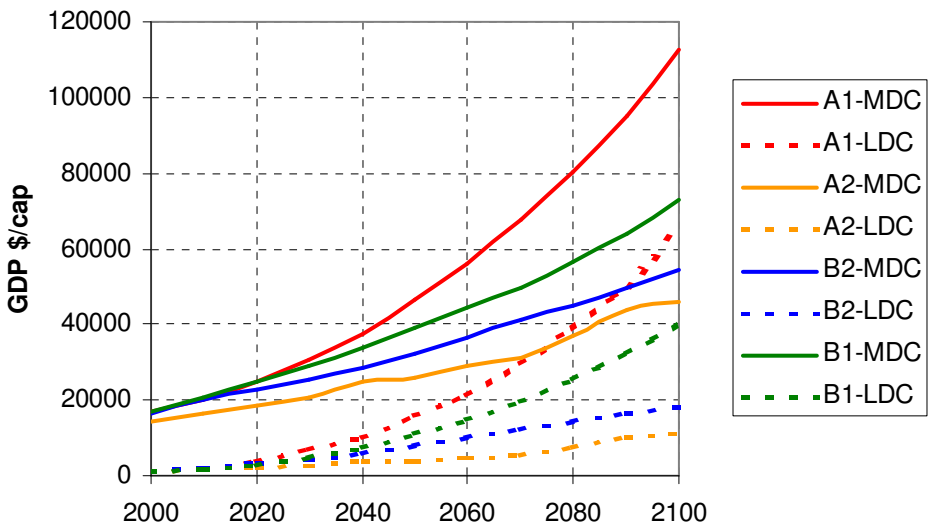
Source: IPCC, 2001.

IPCC SRES Development Scenarios to 2100

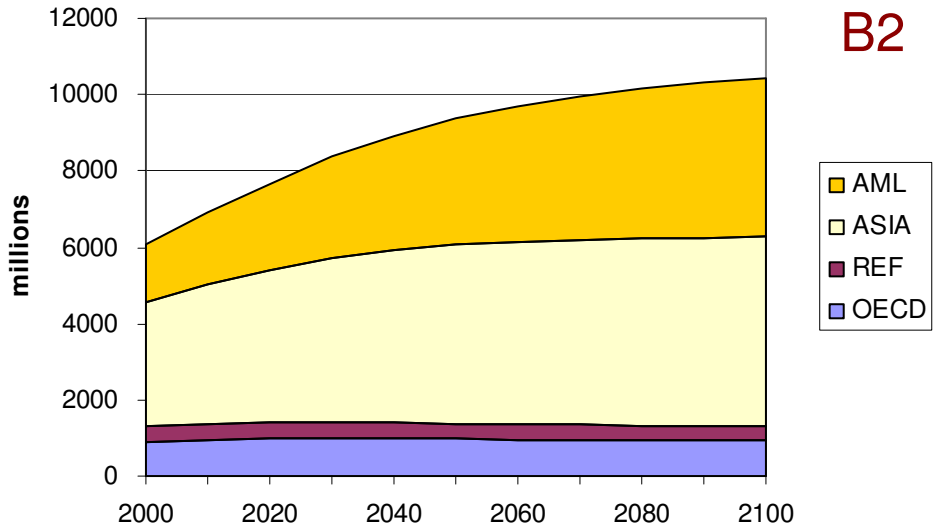
Population, Scenario A1, B1



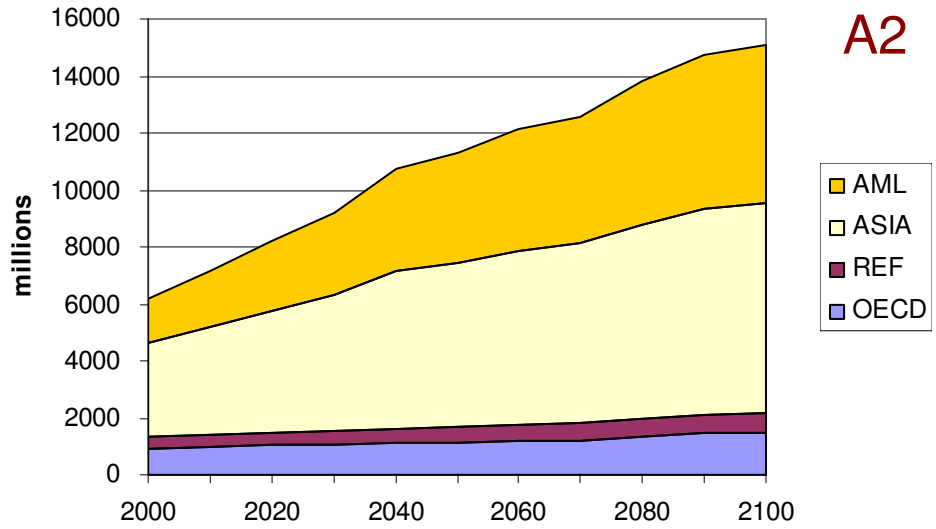
GDP per caput



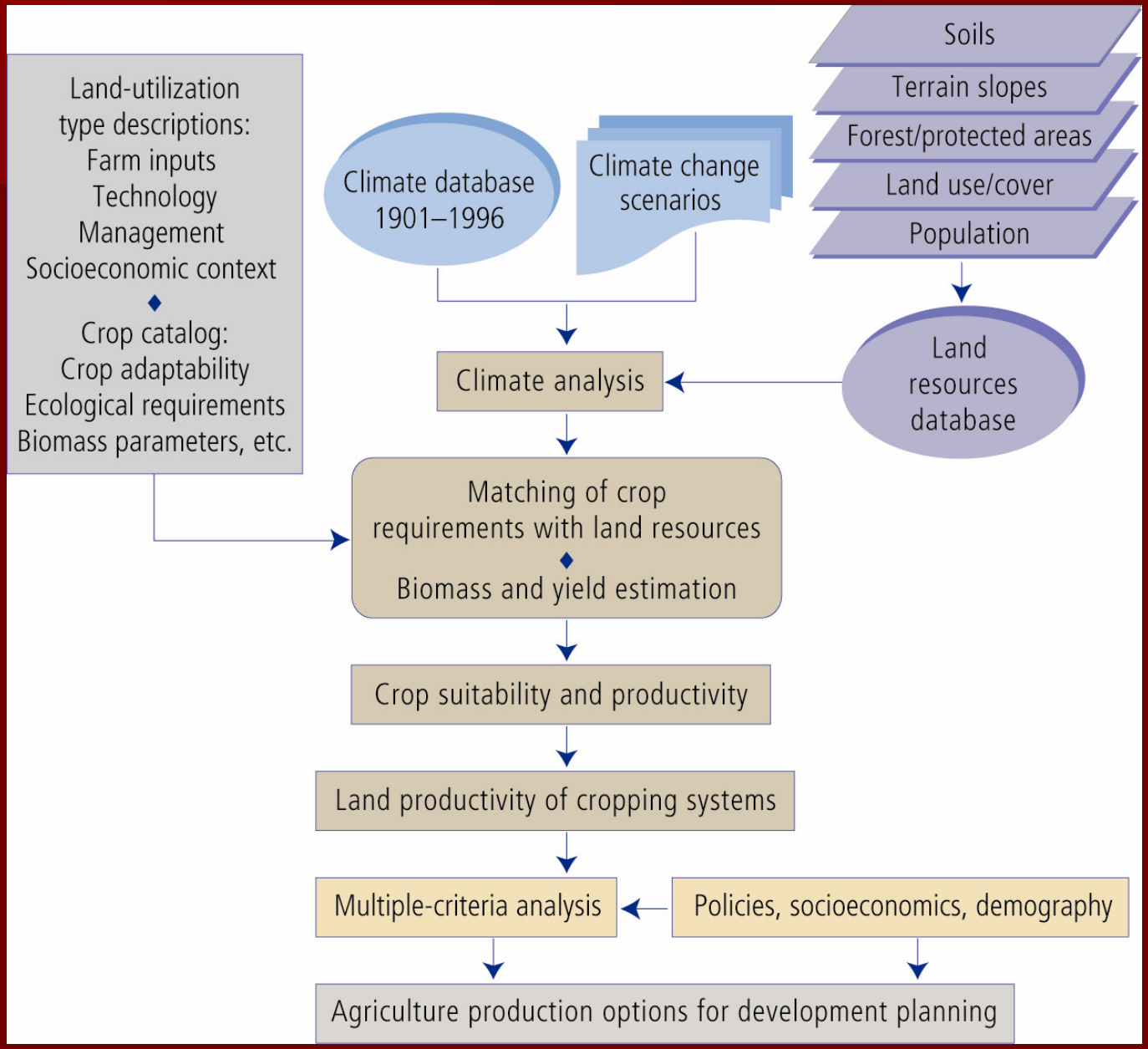
Population, Scenario B2



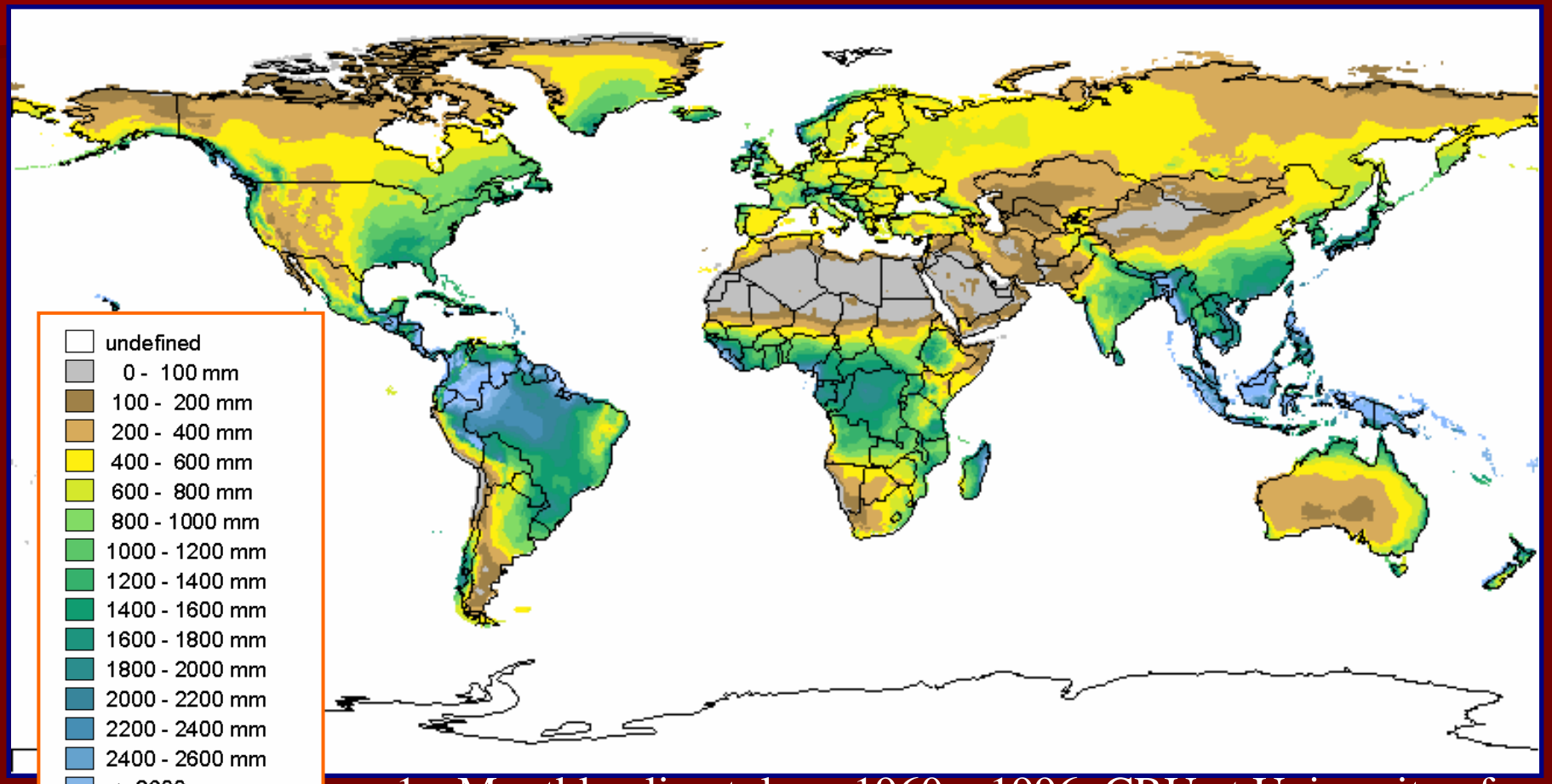
Population, Scenario A2



Agro-ecological Zones Methodology



Agro-ecological Zones Methodology
Geographical Data Layers



1. Monthly climatology 1960 – 1996; CRU at University of East Anglia; at 0.5 deg. latitude/longitude

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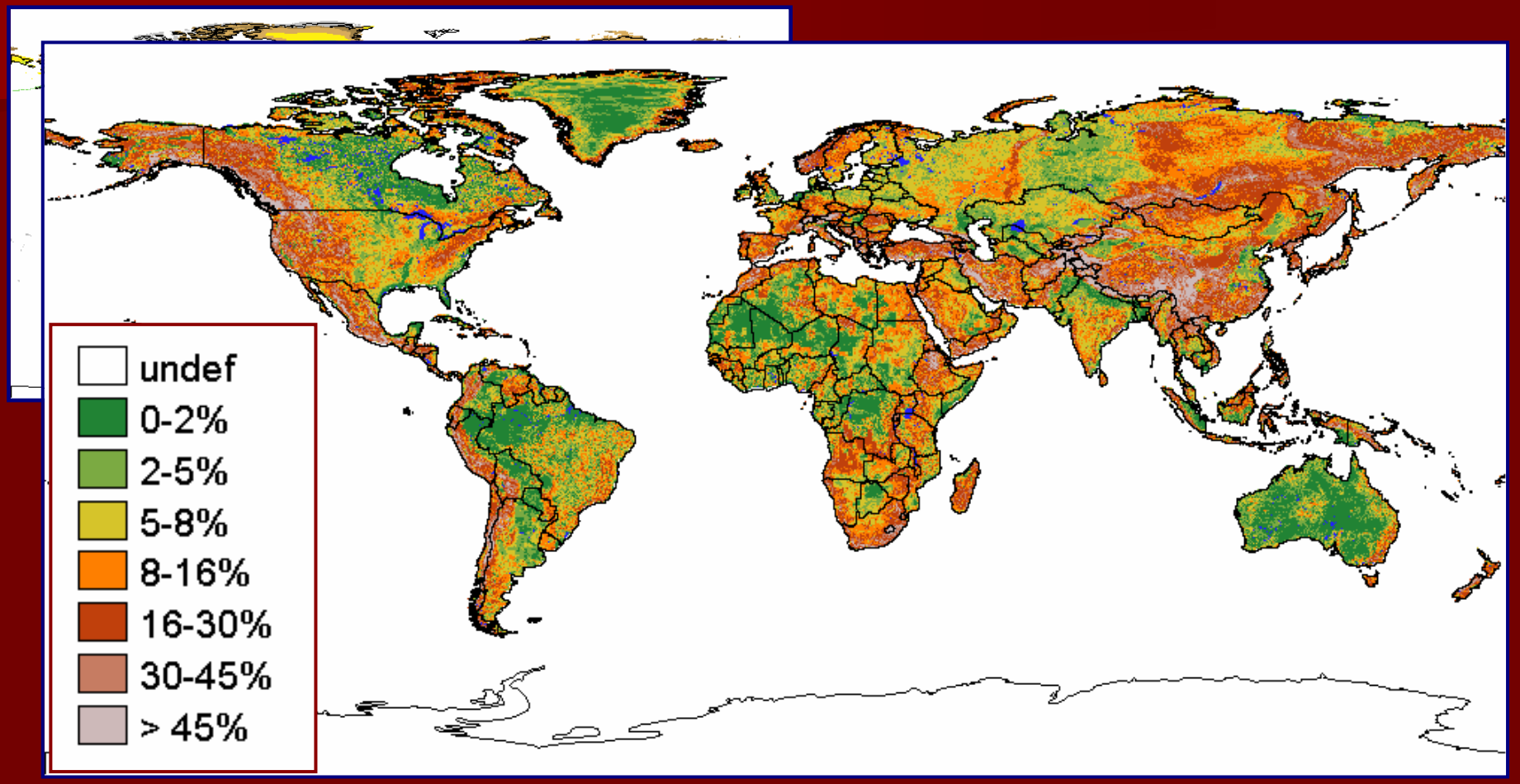
Agro-ecological Zones Methodology
Geographical Data Layers



2. Terrain slope database; USGS Eros Data Center; digital elevation at 30 arc-seconds latitude/longitude

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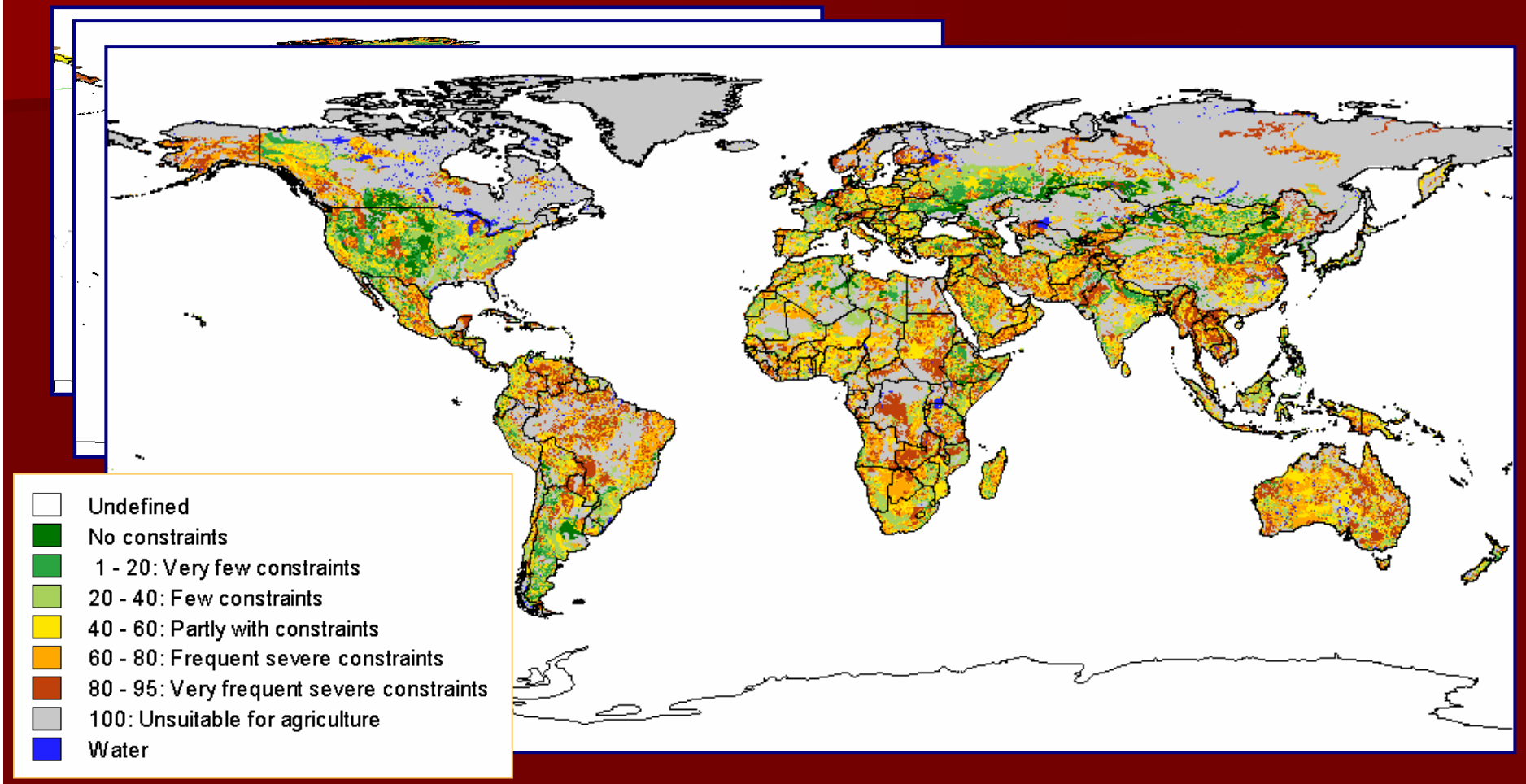
Agro-ecological Zones Methodology
Geographical Data Layers



3. FAO/Unesco digital Soil Map of the World; UN Food and Agriculture Organization; at 5 arc-min. latitude/longitude

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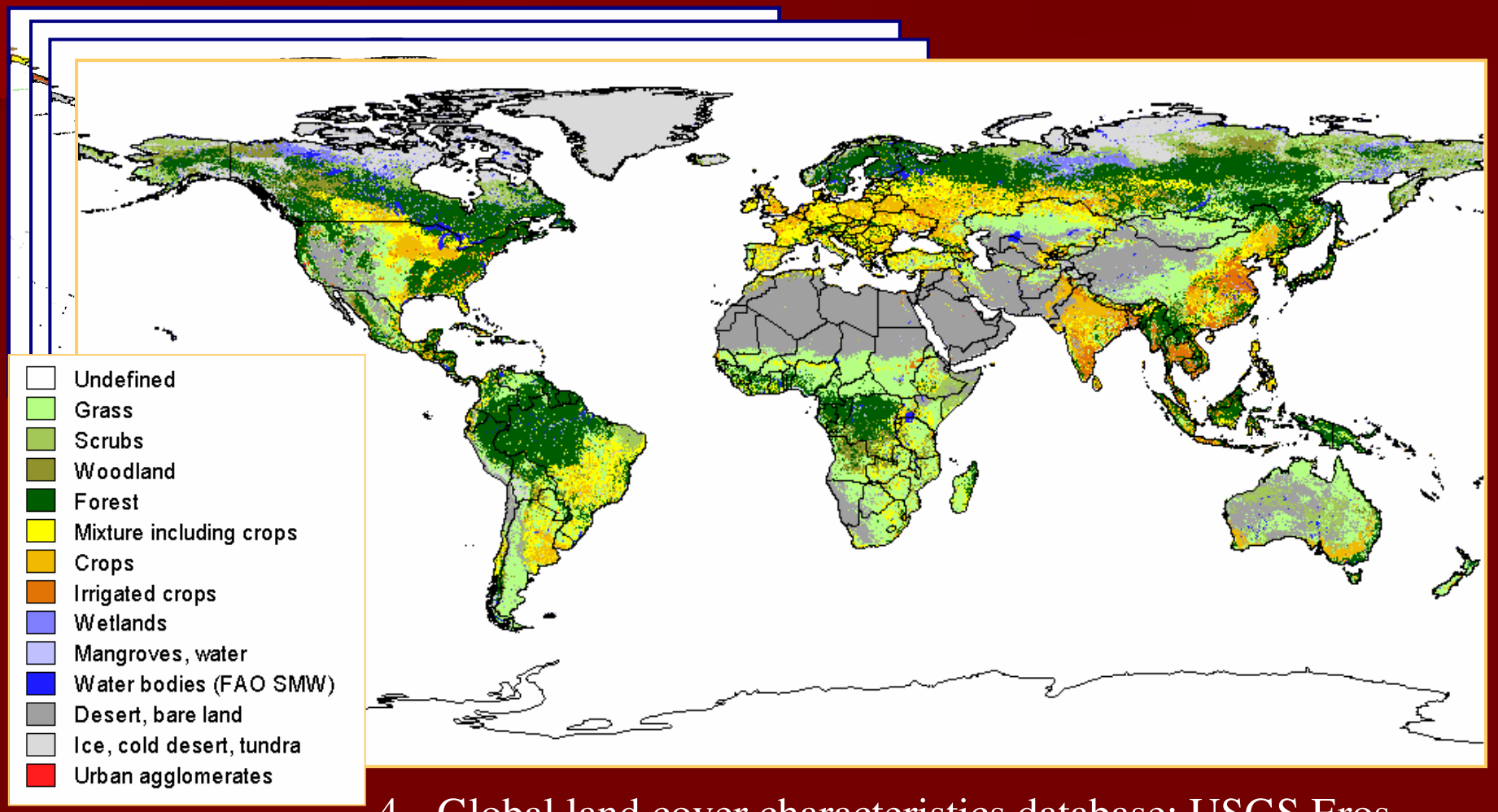
Agro-ecological Zones Methodology
Geographical Data Layers



4. Global land cover characteristics database; USGS Eros Data Center; at 1 km resolution.

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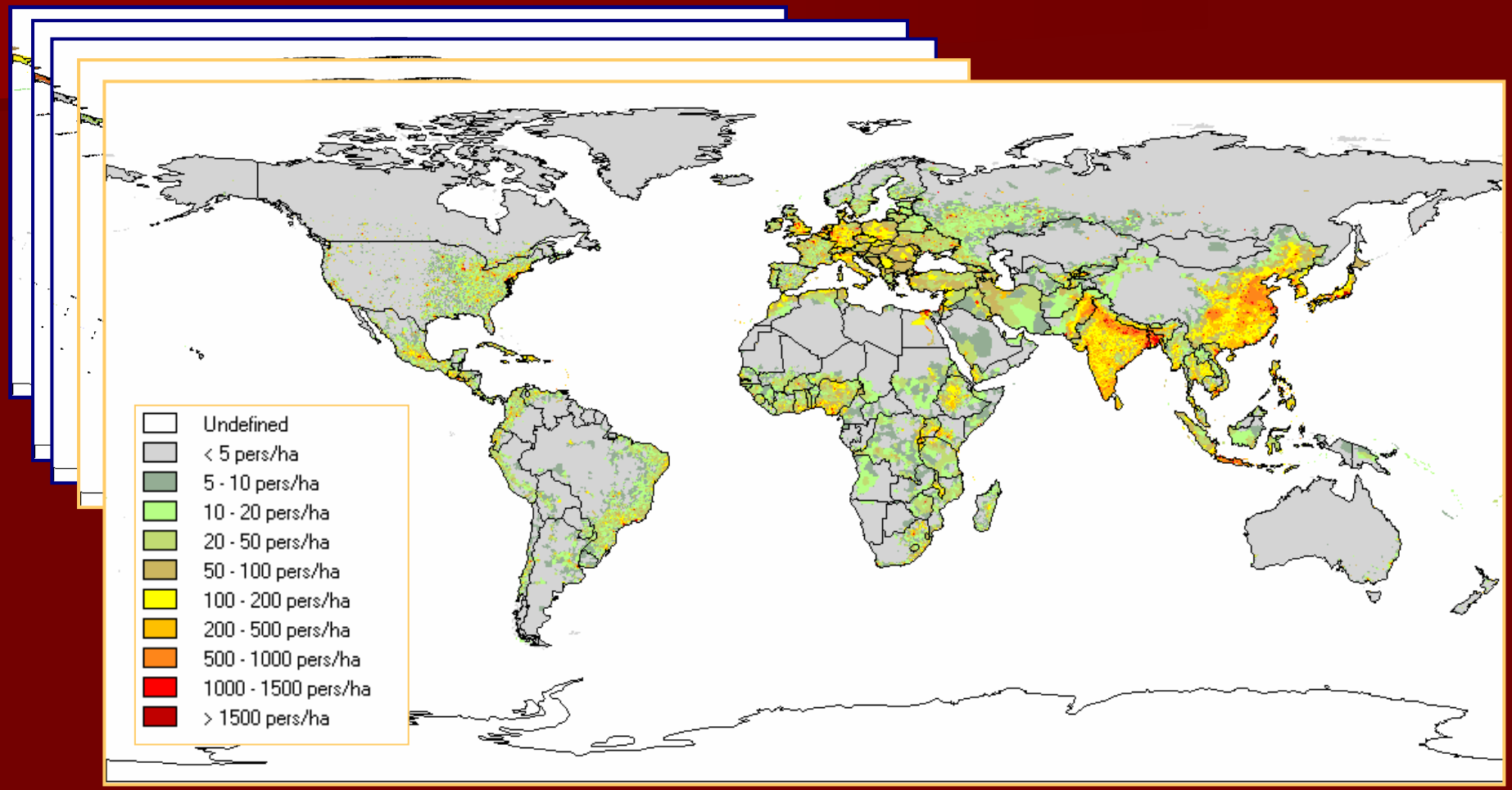
Agro-ecological Zones Methodology
Geographical Data Layers



5. Global gridded population distribution data of 1995; CIESIN; at 2.5 arc-min. latitude/longitude resolution.

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Global Agro-ecological Zones

Environmental resources database

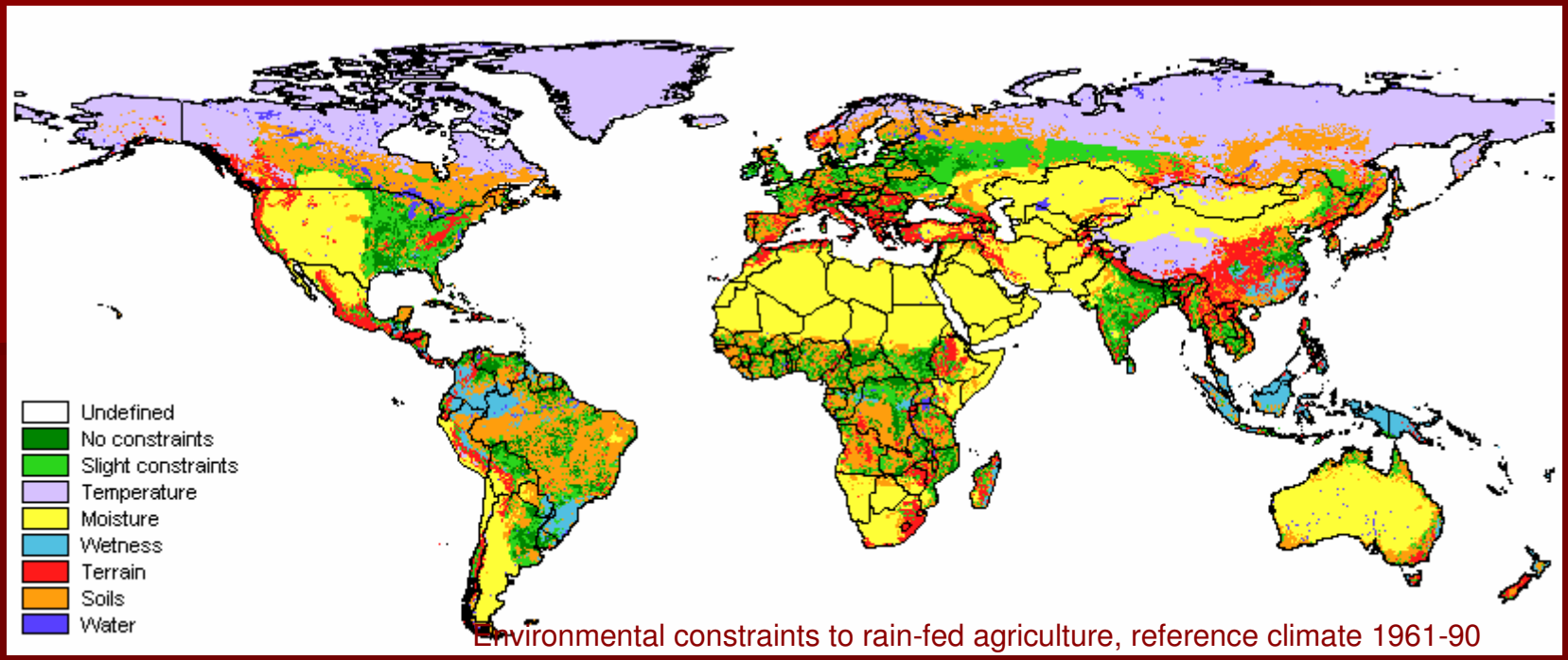
including climate, soil, terrain, and land cover

comprising 2.2 million grid cells,

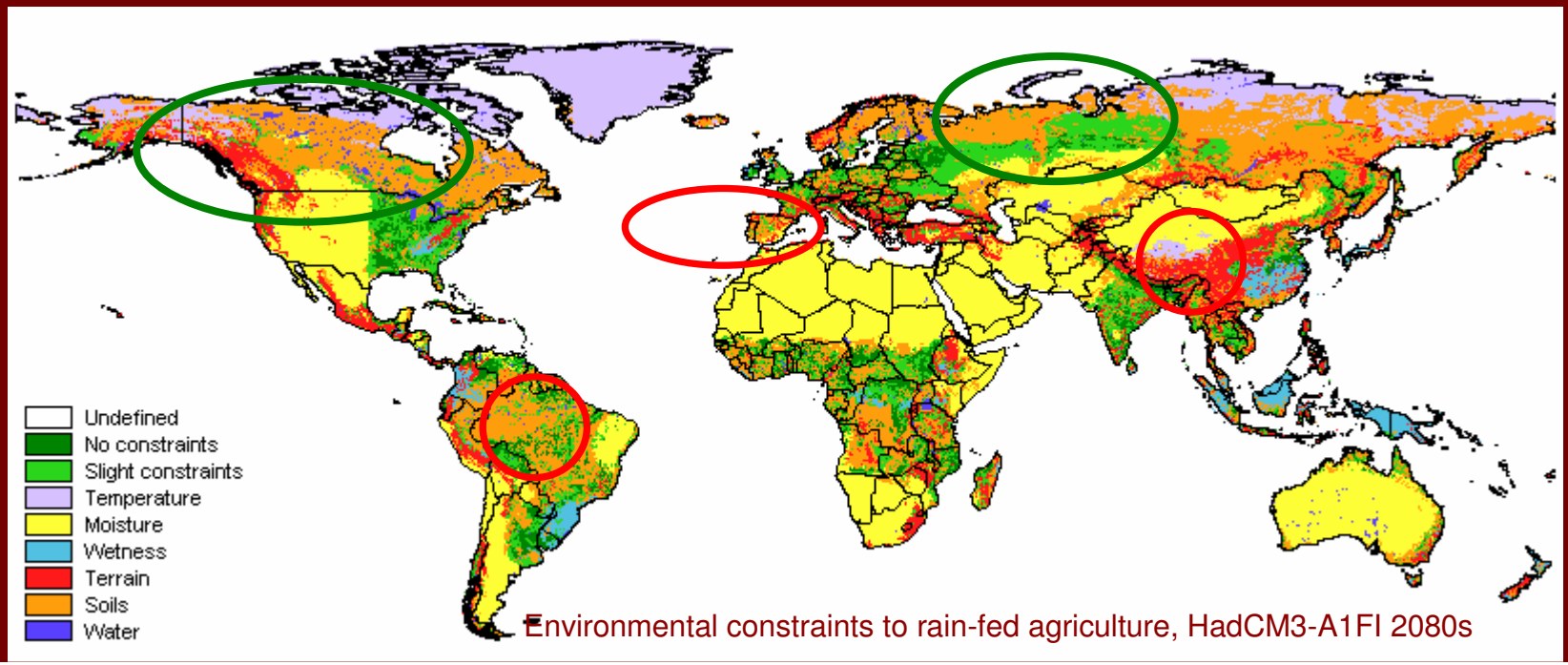
assessing the agricultural potential

of all crops, pastures, trees, shrubs

at three levels of farming technology.



Environmental constraints to rain-fed agriculture, reference climate 1961-90



Environmental constraints to rain-fed agriculture, HadCM3-A1FI 2080s

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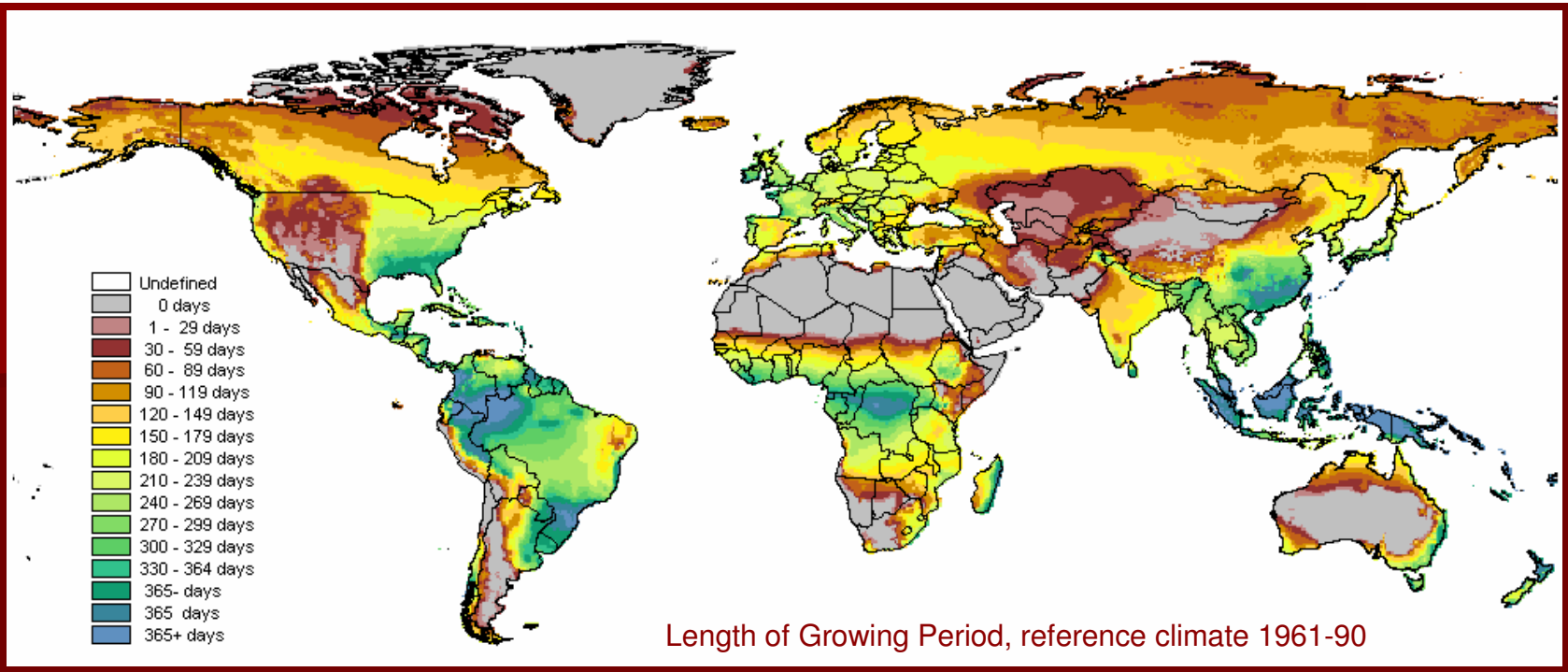
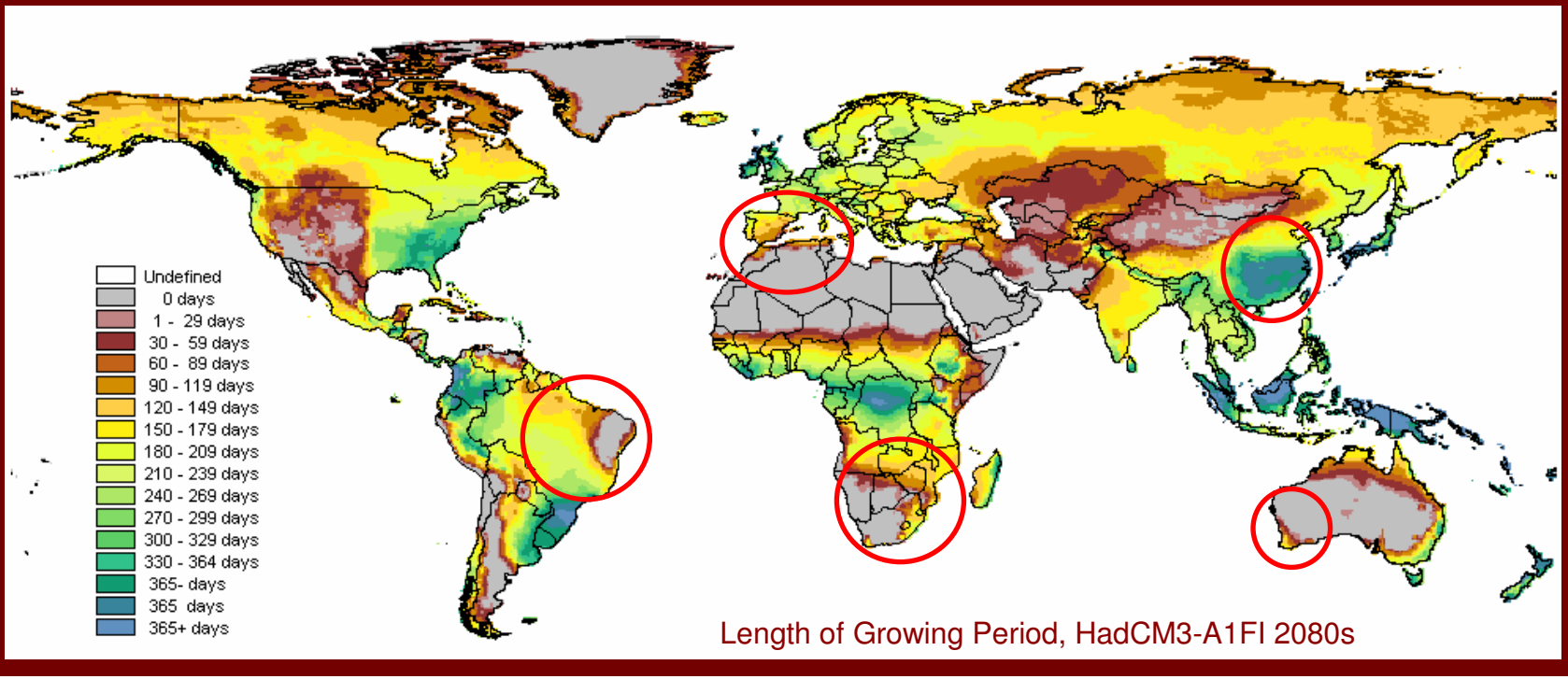


Length of Growing Period, reference climate 1961-90



Length of Growing Period, HadCM3-A1FI 2080s

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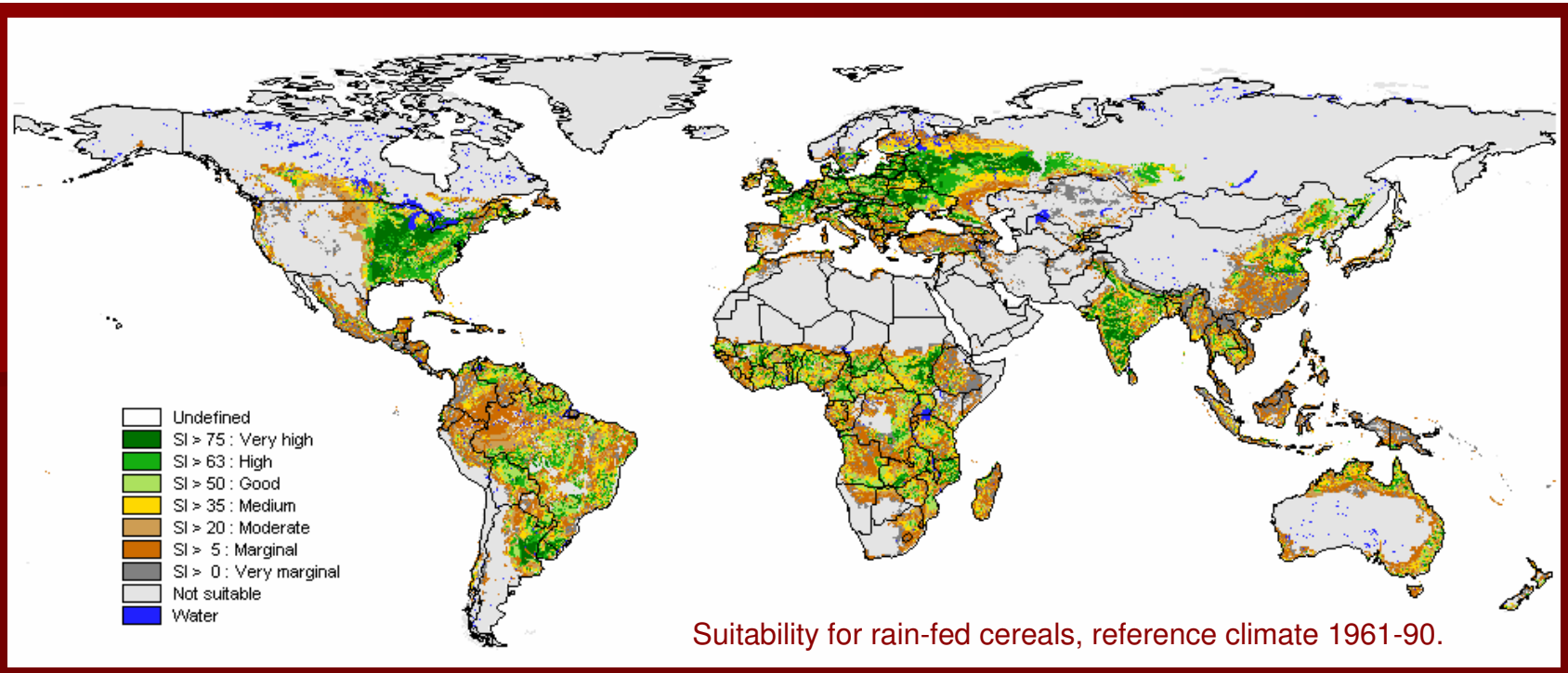
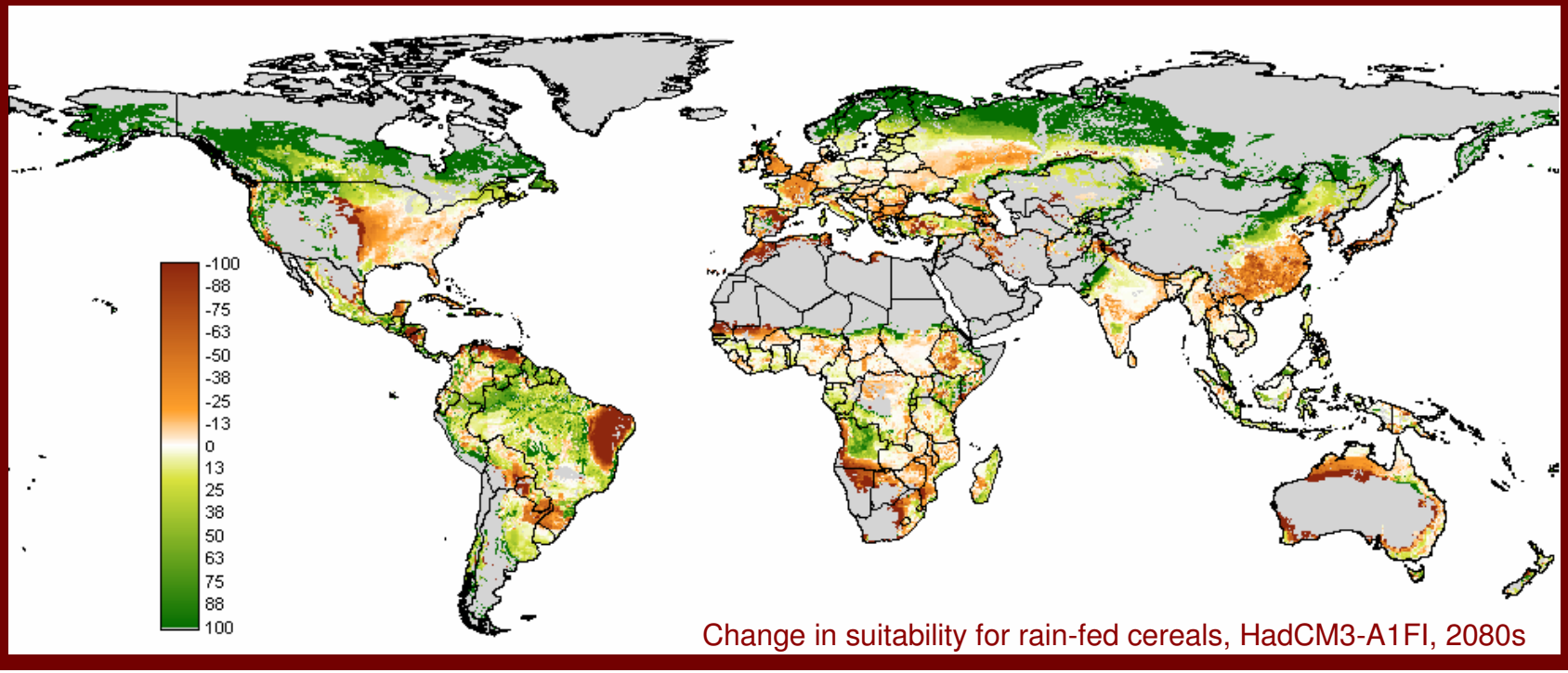


Suitability for rain-fed cereals, reference climate 1961-90.



Change in suitability for rain-fed cereals, HadCM3-A1FI, 2080s

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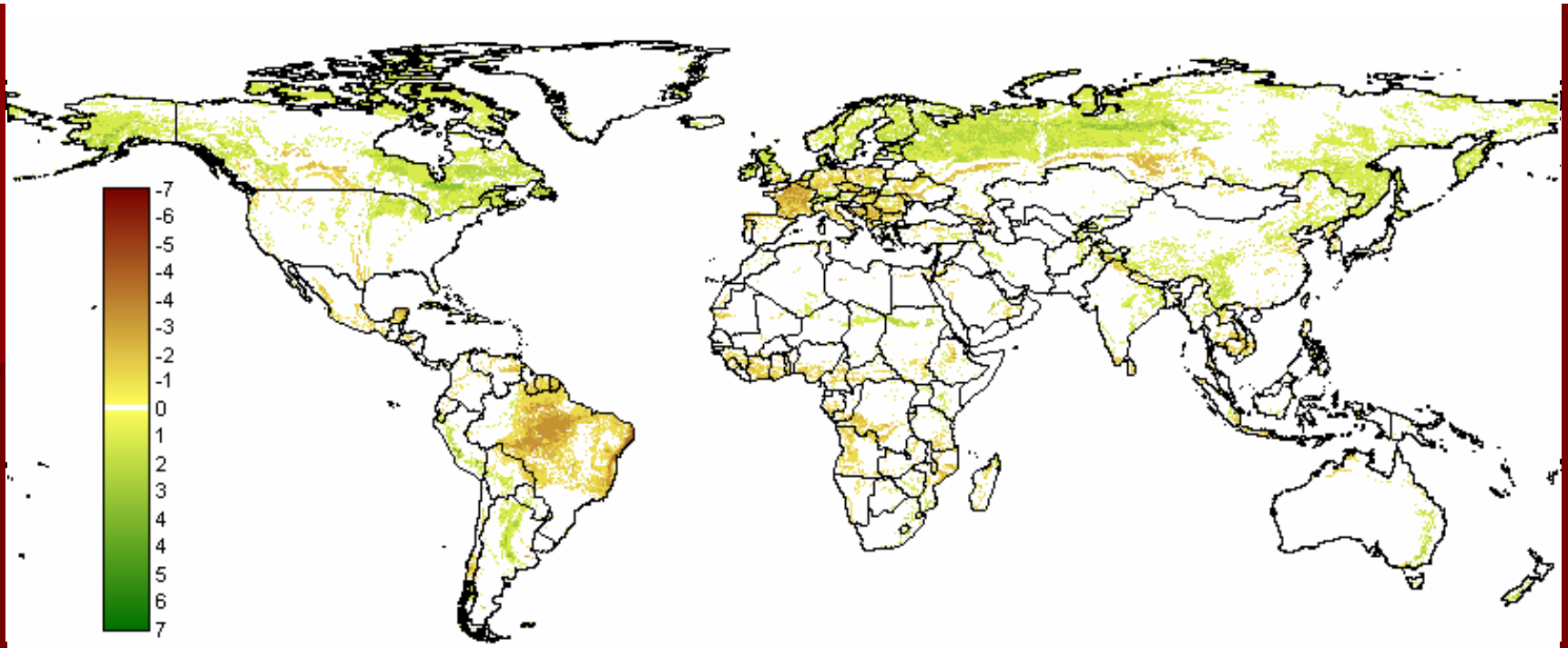

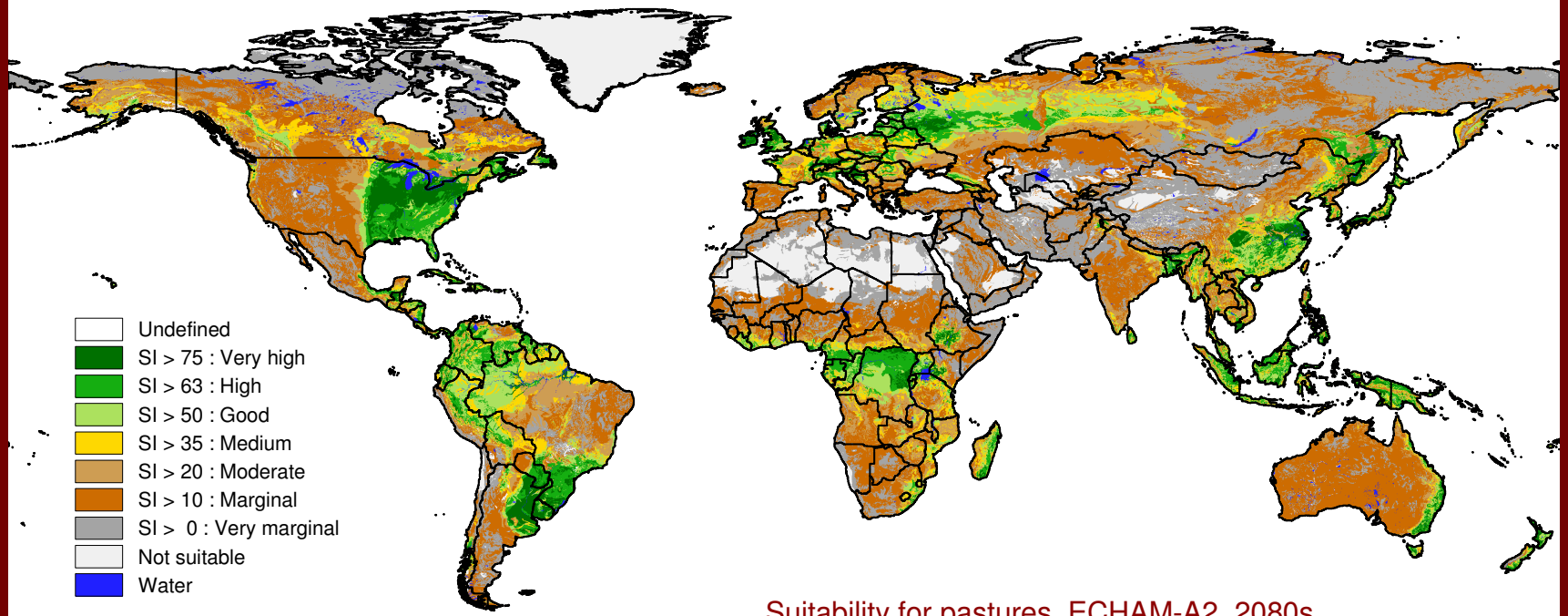

Suitability for pastures, ECHAM-A2, 2080s.

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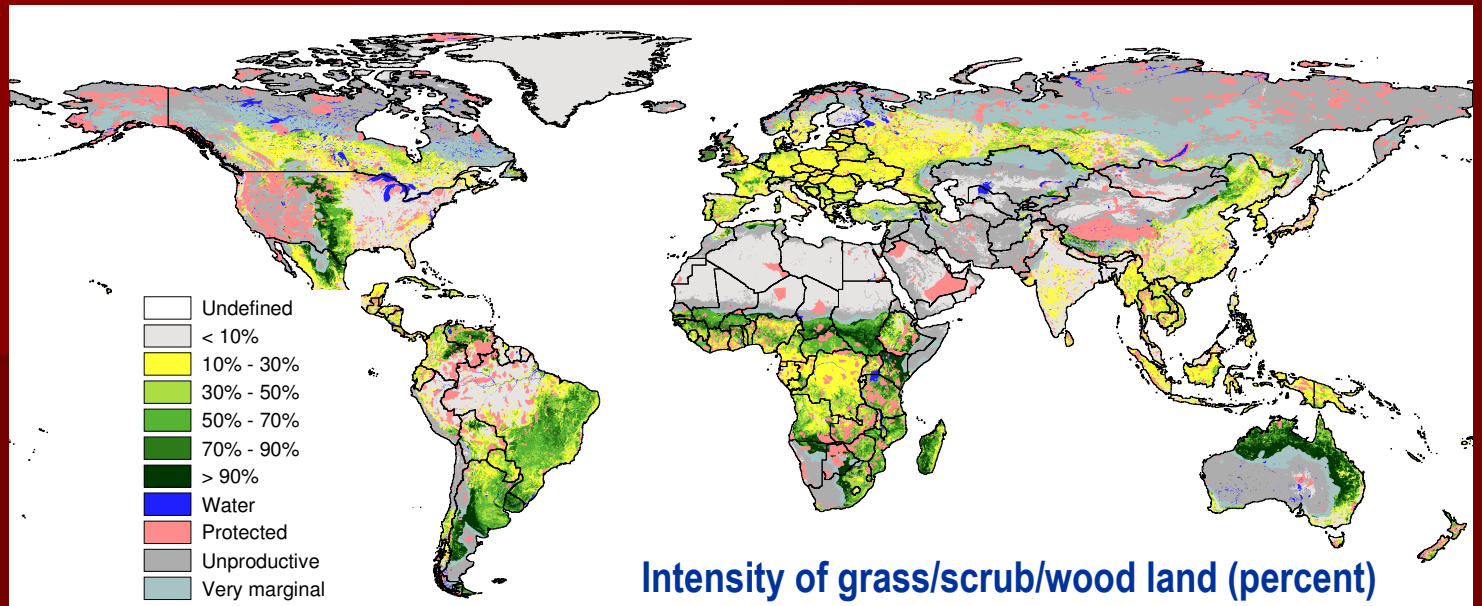
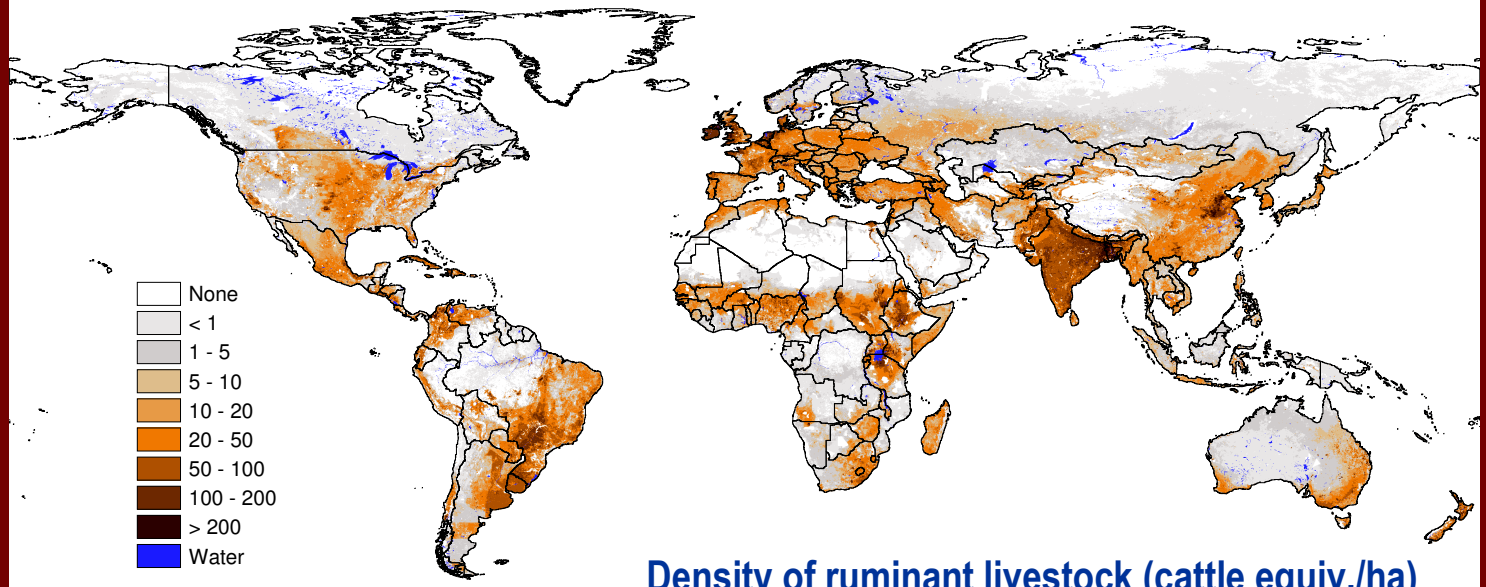


Intensity of grass/scrub/wood land (percent)



Density of ruminant livestock (cattle equiv./ha)

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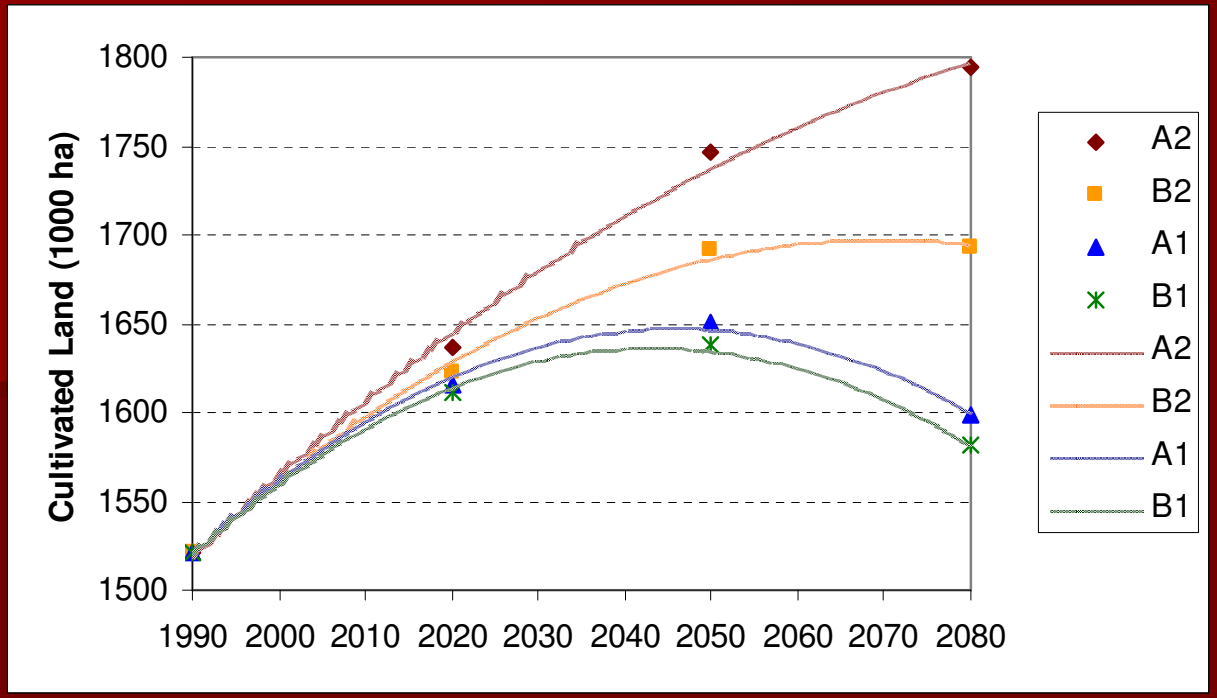
Cultivated Land

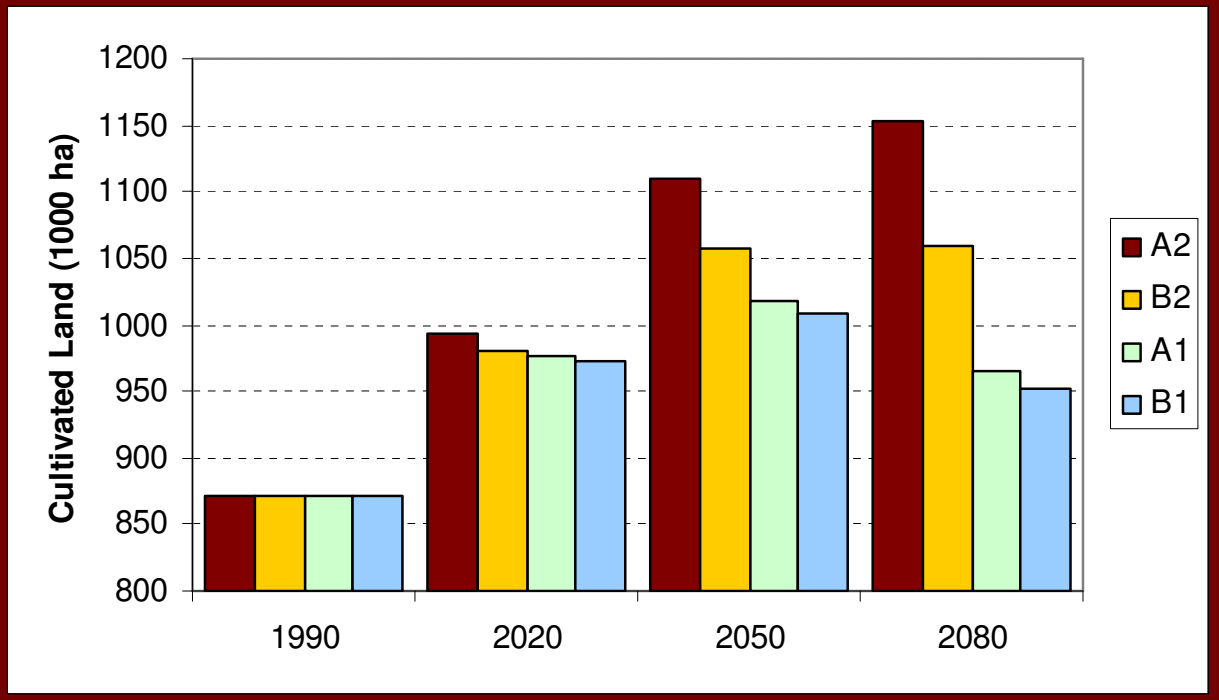
projected for different IPCC economic development paths



WORLD

Source: Fischer et al., 2002

DEVELOPING COUNTRIES



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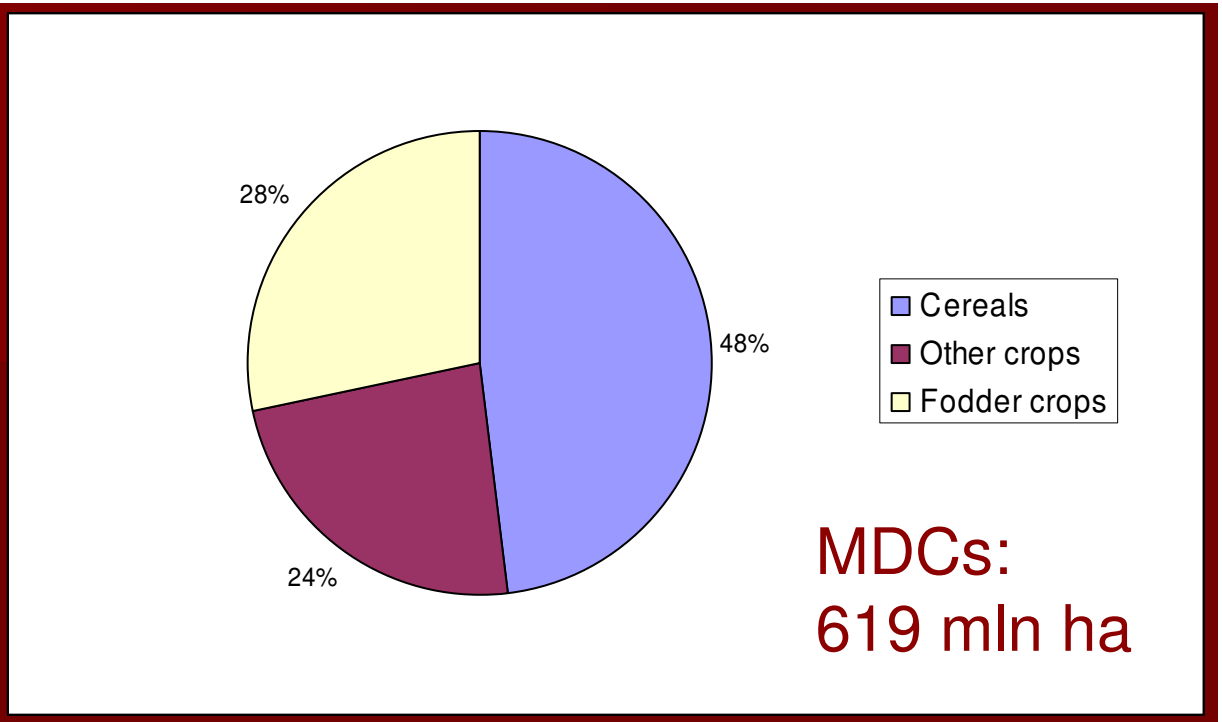
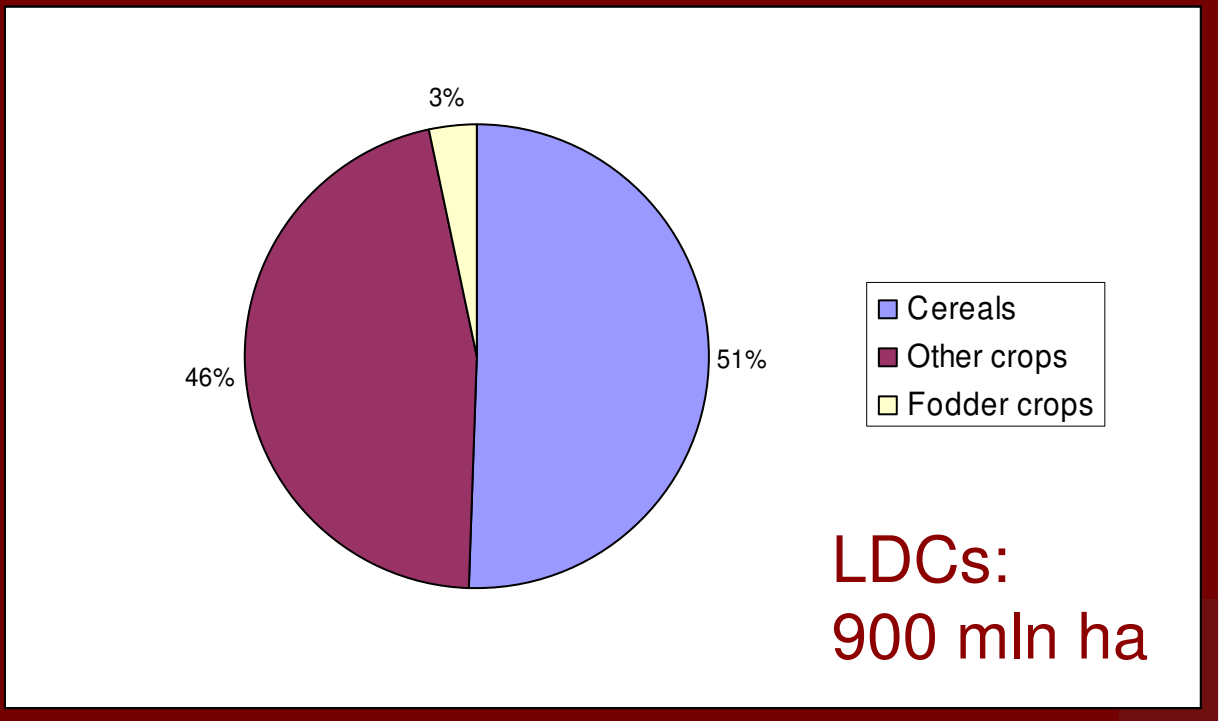
Global Use of Arable Land, year 2000

Land in consumption	World mln ha
Crops (excl feed)	1005.4
Cereals	536.9
Other crops	468.5
Feed use	514.1
Cereals	214.2
Other crops	94.4
Fodder crops	205.5
of which	
Ruminants	307.7
Other livestock	206.4

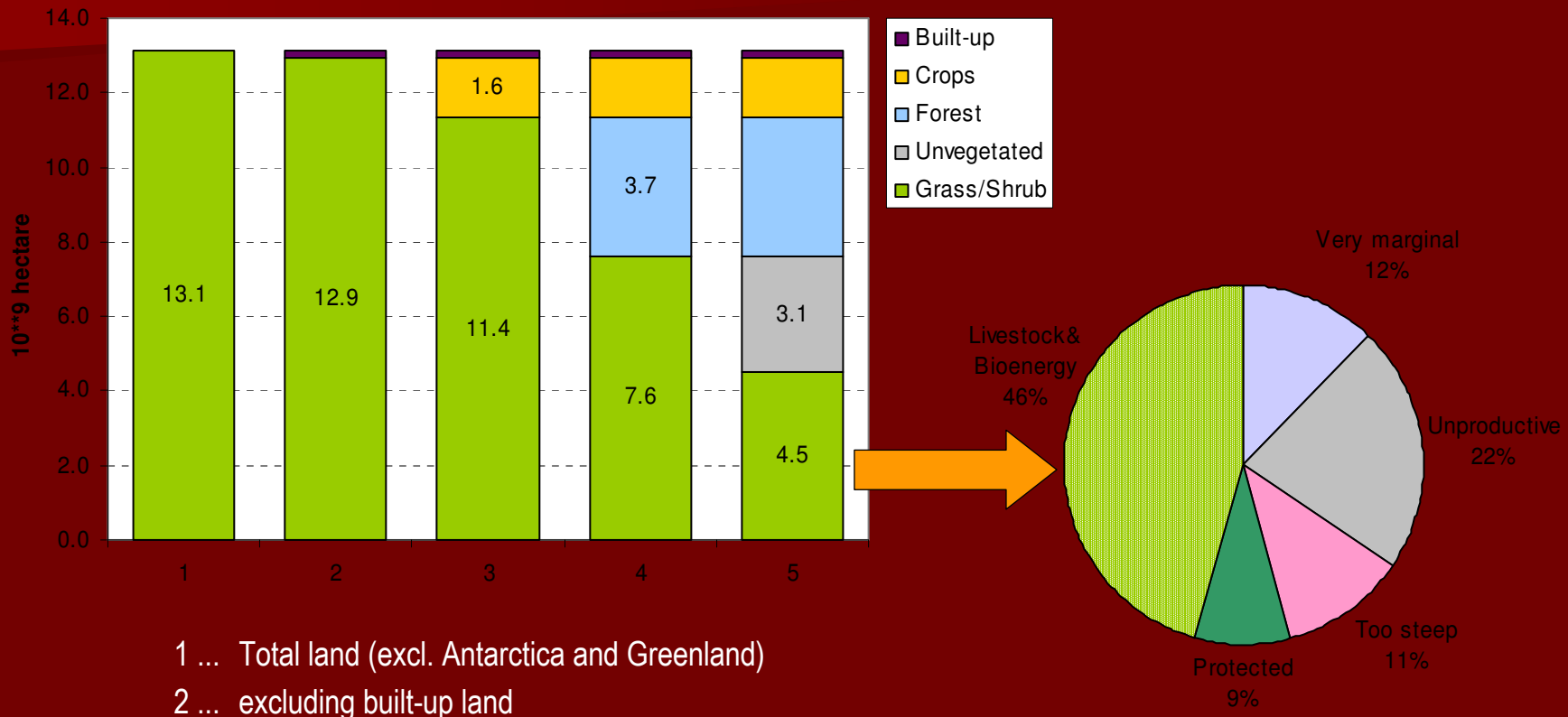


MDCs:
619 mln ha



LDCs:
900 mln ha

How much land is available?



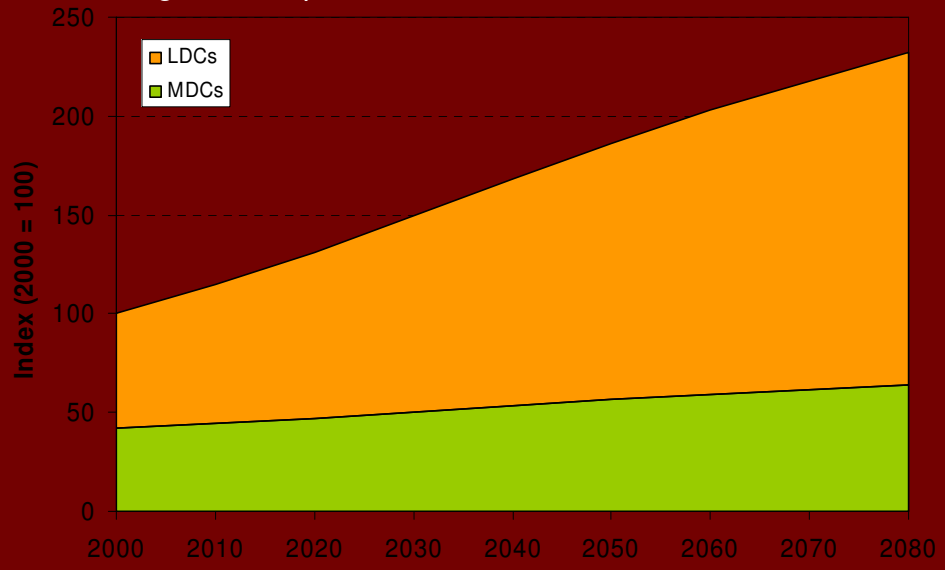
1 ... Total land (excl. Antarctica and Greenland)
2 ... excluding built-up land
3 ... excluding arable and perennial cropland
4 ... excluding forests
5 ... excluding barren land & water

Source: IIASA-LUC, 2007

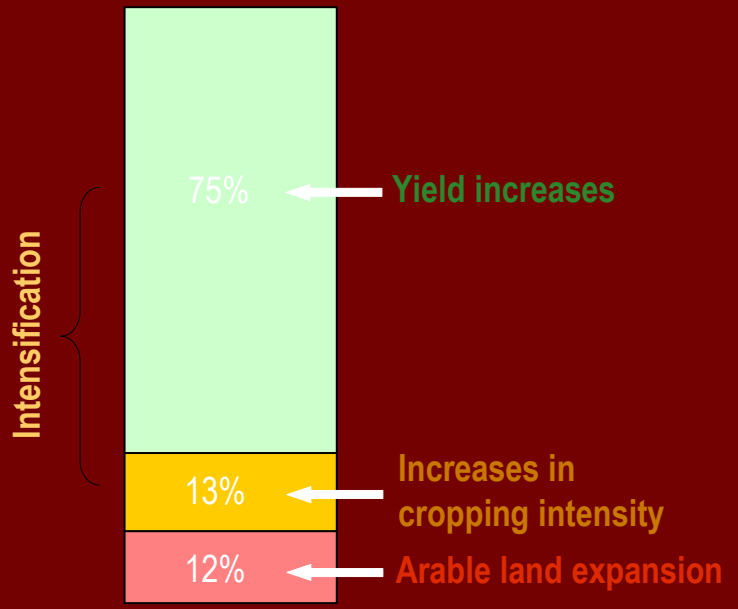
Food and Agriculture Outlook

Growth of:	2000-2050
Arable land	12%
Cereal production	69%
Ruminant meat	73%
Other meat	85%
Agriculture	86%

Index of agricultural production, IIASA A2r scenario, 2000-2080



Sources of growth in agricultural production, Scenario A2r, 2000-2050



Source: World Food System simulations of IIASA GGI scenarios, Fischer et al. (2005).

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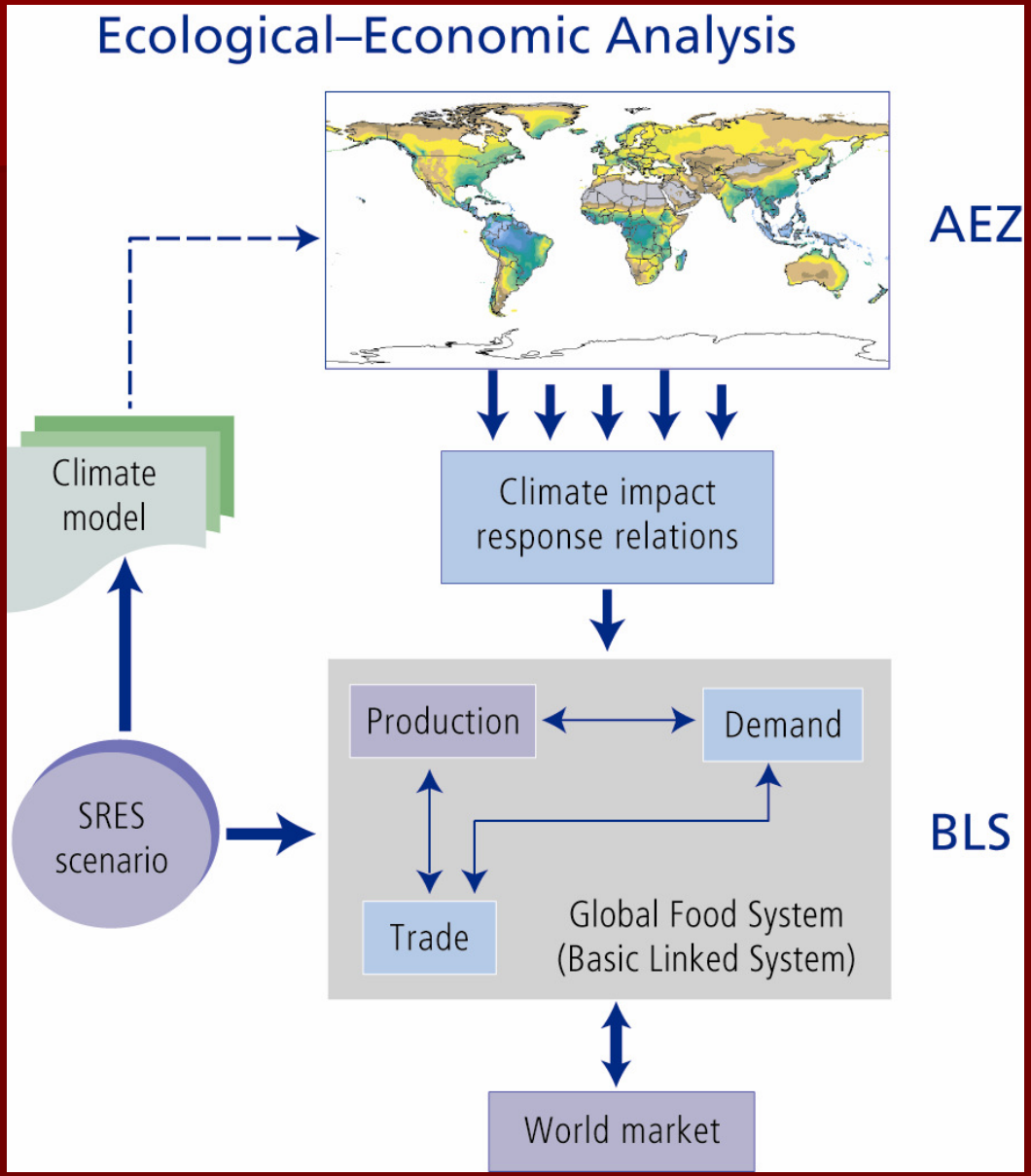
Integrated ecological-economic Analysis of the Impact of Climate Change on Food and Agriculture Systems

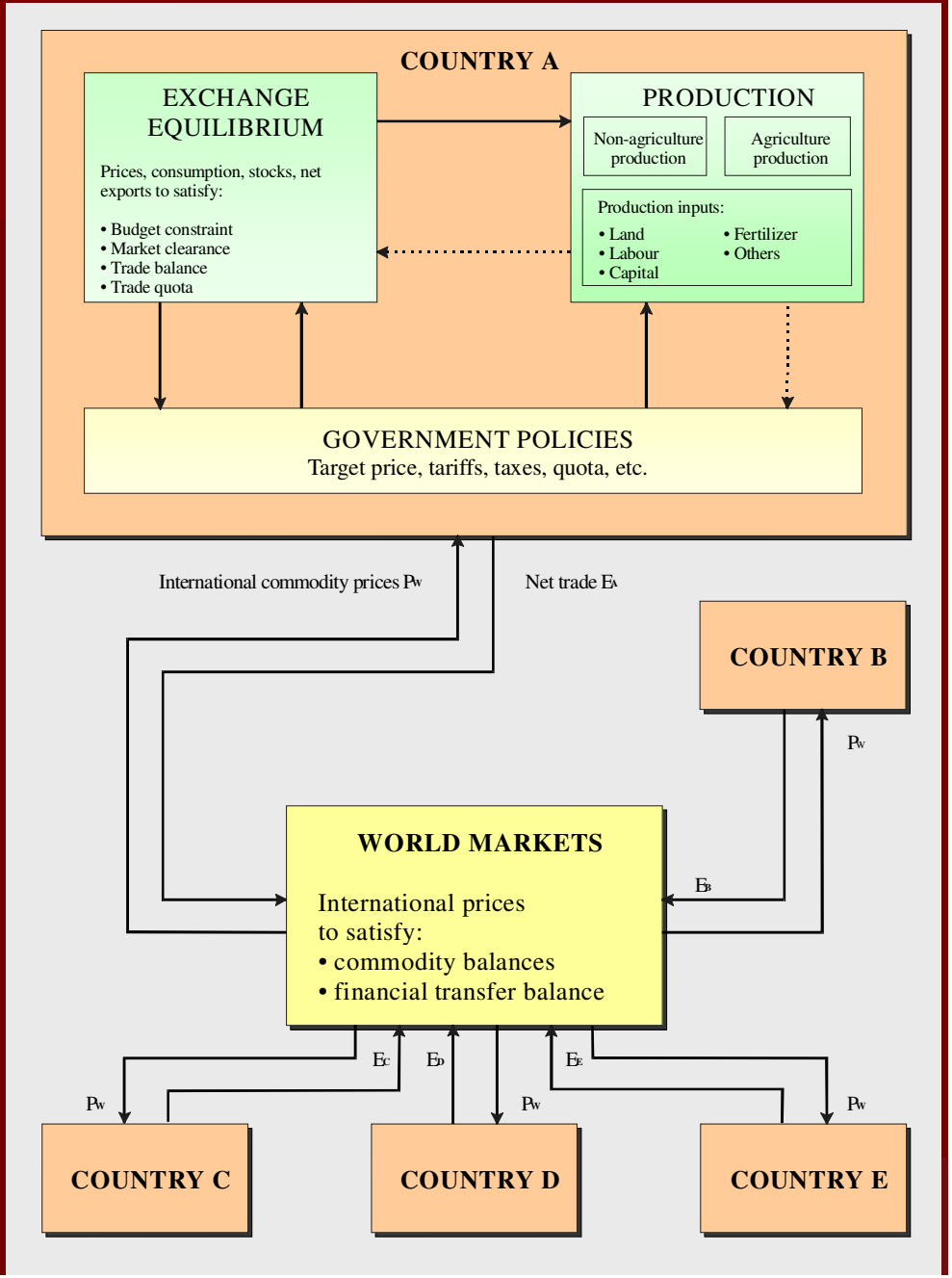


The International Linkage in the World Food System Model

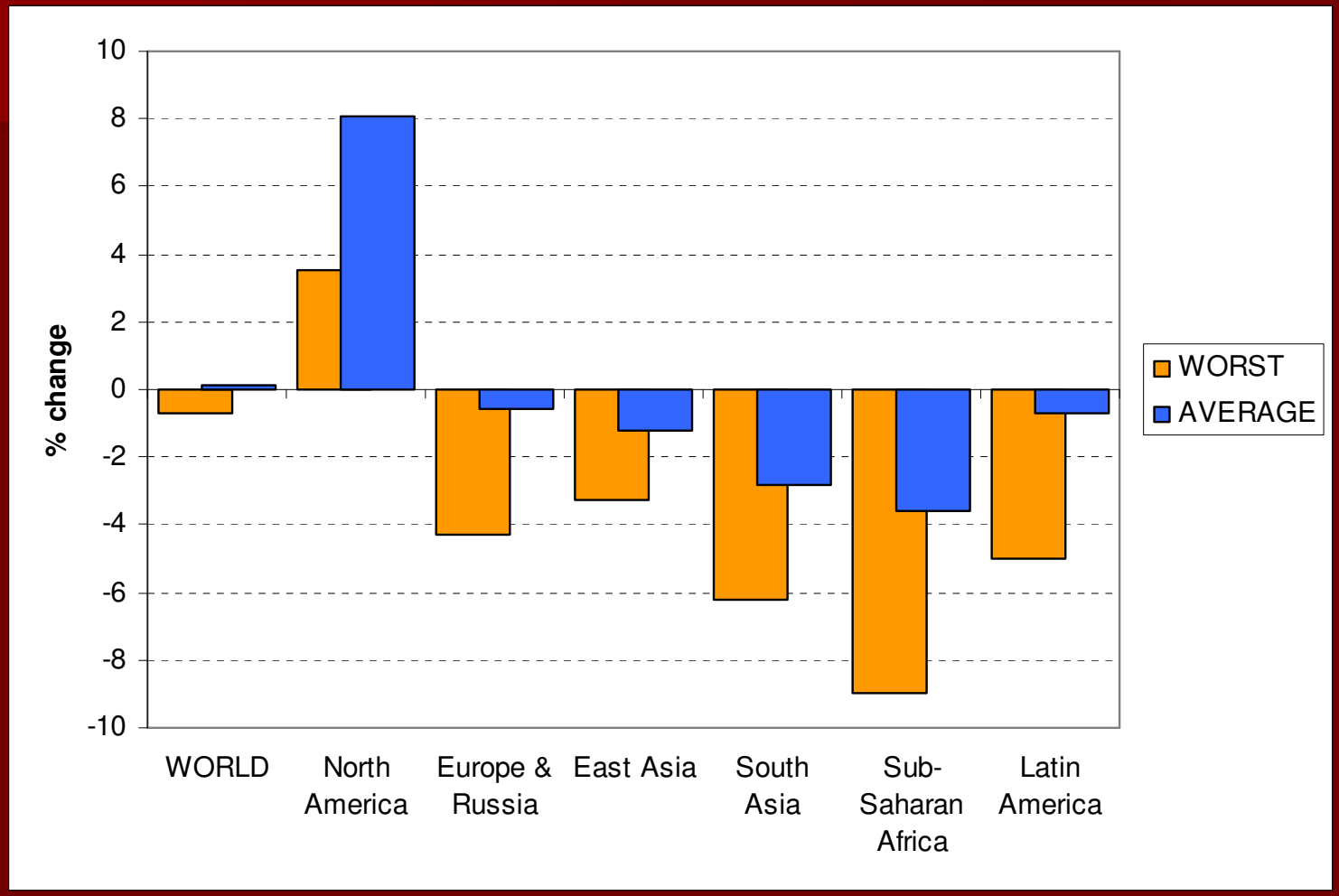
18 national models,
2 country-group models,
14 regional models

Commodities: wheat, rice, coarse grains, protein feed, bovine & ovine meat, dairy products, other animal products, other food, non-food agriculture, non-agriculture.

Linkage: trade, world market prices and financial flows



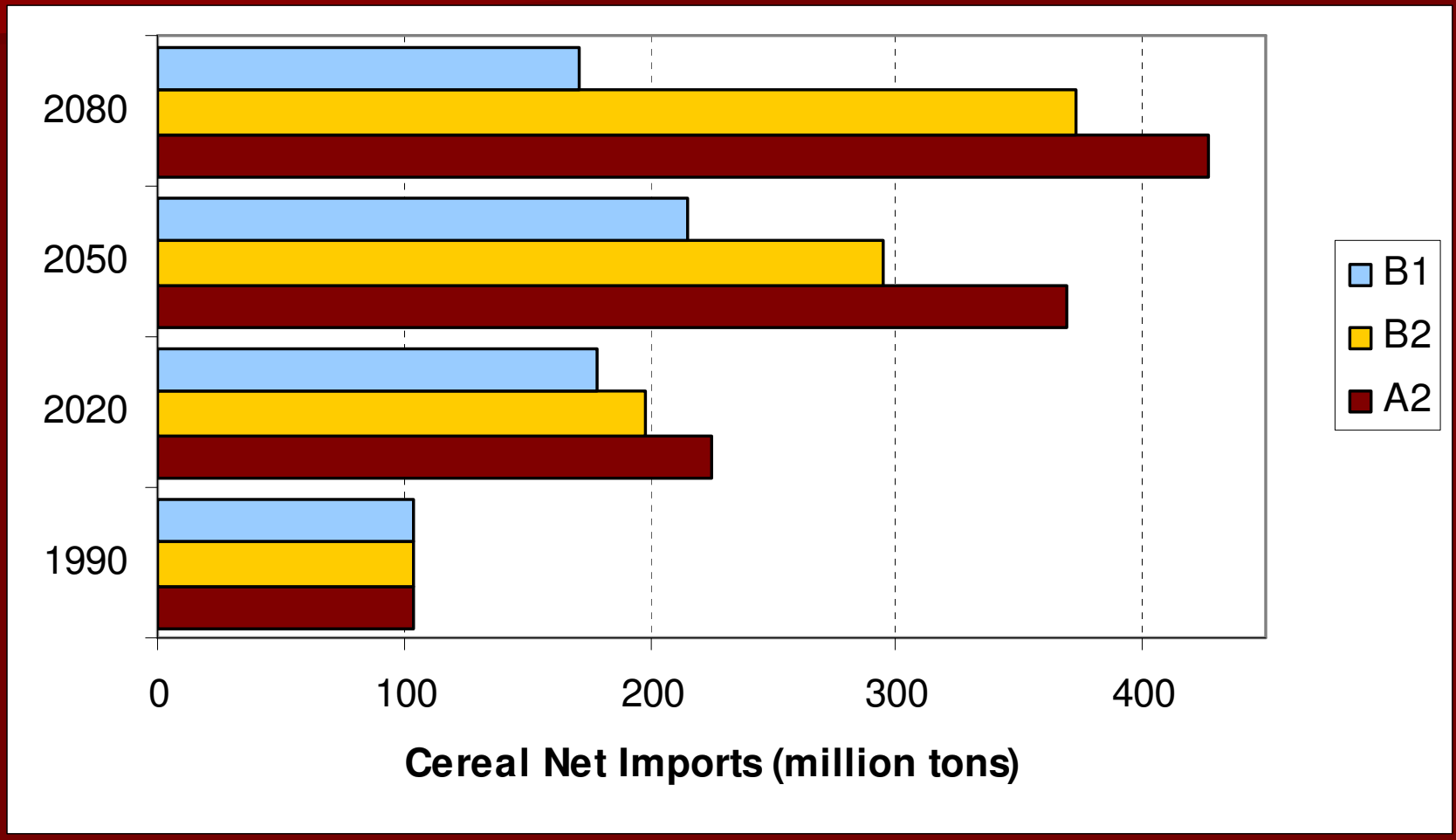
Simulated Impacts of Climate Change on Regional Crop and Livestock Production – 2080s



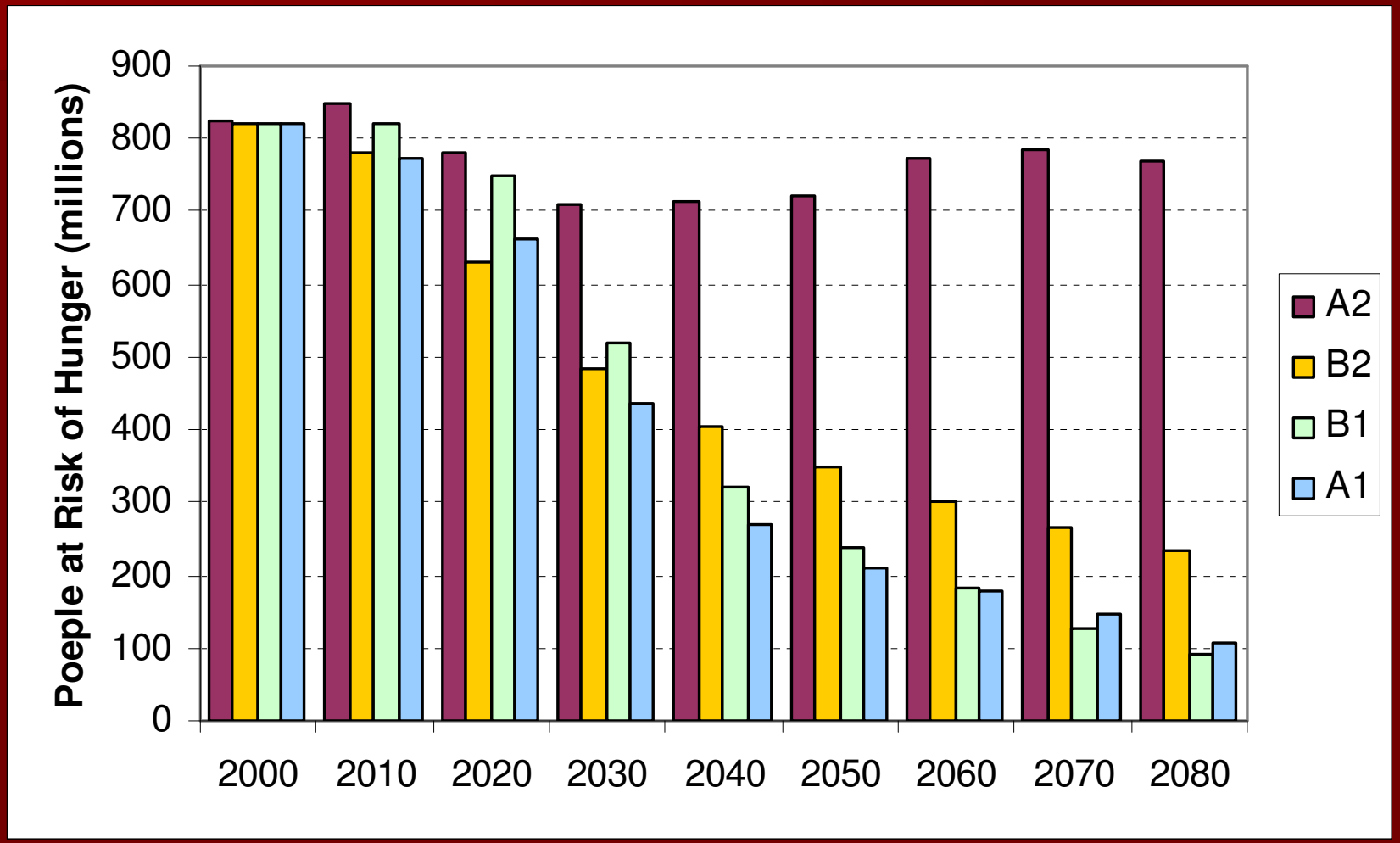
Note: percent changes relative to SRES A2 reference projection without climate change. The diagram is based on food system simulations using climate projections obtained from four climate models for the IPCC SRES A2 emissions scenario.

Cereal Net Imports of Developing Countries

projected for different IPCC economic development paths



Number of People at Risk of Hunger
projected for different IPCC economic development paths



Source: Fischer et al., 2002

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Economic Impacts of Climate Change Hadley A1F1 Scenario 2080

	% Ag GDP	% Cereal Production
World	-1.5	-1.4
Developed	-0.5	2.8
North America	7.5	1.3
Europe	-14.7	-3.4
Devloping	-1.9	-3.9
Africa	-4.9	-0.6
Latin america	3.7	15.9
Asia	-4.3	-8.6

World Market prices(% change from Ref Scenario)

Cereals 19.5% All crops 10.5%

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India :Climate Change Yield Impact - 2080

	Wheat	Rice	Maize	Pulses	Roots	Oil	Sugar
H3A1f	-41.5	0.2	-2.5	6.1	-7.5	-5.3	-9.8
H3A2	-36.6	-3.6	-3.1	1.4	-23.9	-8.8	-9.6
H3B2	-20.8	-3.3	-2.8	3.0	-9.3	-6.5	-8.9
H3B1	-15.6	0.5	-0.8	5.9	3.8	-0.6	-6.3
CSA1	-25.2	-0.1	-0.4	9.6	1.8	-2.4	-8.0
CSA2	-25.8	-1.1	-1.0	6.7	-4.8	-4.5	-9.7
CSB2	-18.3	-2.7	-1.2	5.6	-1.0	-4.7	-8.9
CSB1	-17.3	-1.9	-1.6	5.3	-2.2	-4.0	-7.5
C2A2	-16.5	0.5	2.4	17.2	13.7	2.3	-9.9
C2B2	-17.7	2.4	1.9	17.6	17.4	3.0	-7.5
NCA2	-32.5	4.5	0.6	13.7	19.7	0.3	-6.3
NCB2	-19.4	4.0	-0.5	11.4	19.9	-0.4	-4.7

Note: weighted yield impact for rain-fed and irrigated cultivation (% change).

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India : Impact of Climate Change on Agriculture – 2080s

	Cereal Production	GDP Agriculture	Cereal Consumption
H3A1f	-15.7	-4.8	-7.5
H3A2	-15.9	-7.9	-6.4
H3B2	-9.8	-4.4	-4.4
H3B1	-5.7	-1.0	-3.8
CSA1b	-9.6	-1.8	-4.6
CSA2	-10.4	-3.9	-4.1
CSB2	-8.2	-2.8	-4.9
CSB1	-7.5	-2.7	-5.0
CSA2	-5.7	1.0	-2.2
CSB2	-5.4	2.5	-1.2
NCA2	-10.3	0.9	-0.4
NCB2	-5.7	1.9	0.1

Note: percent change relative to respective reference projection without climate change

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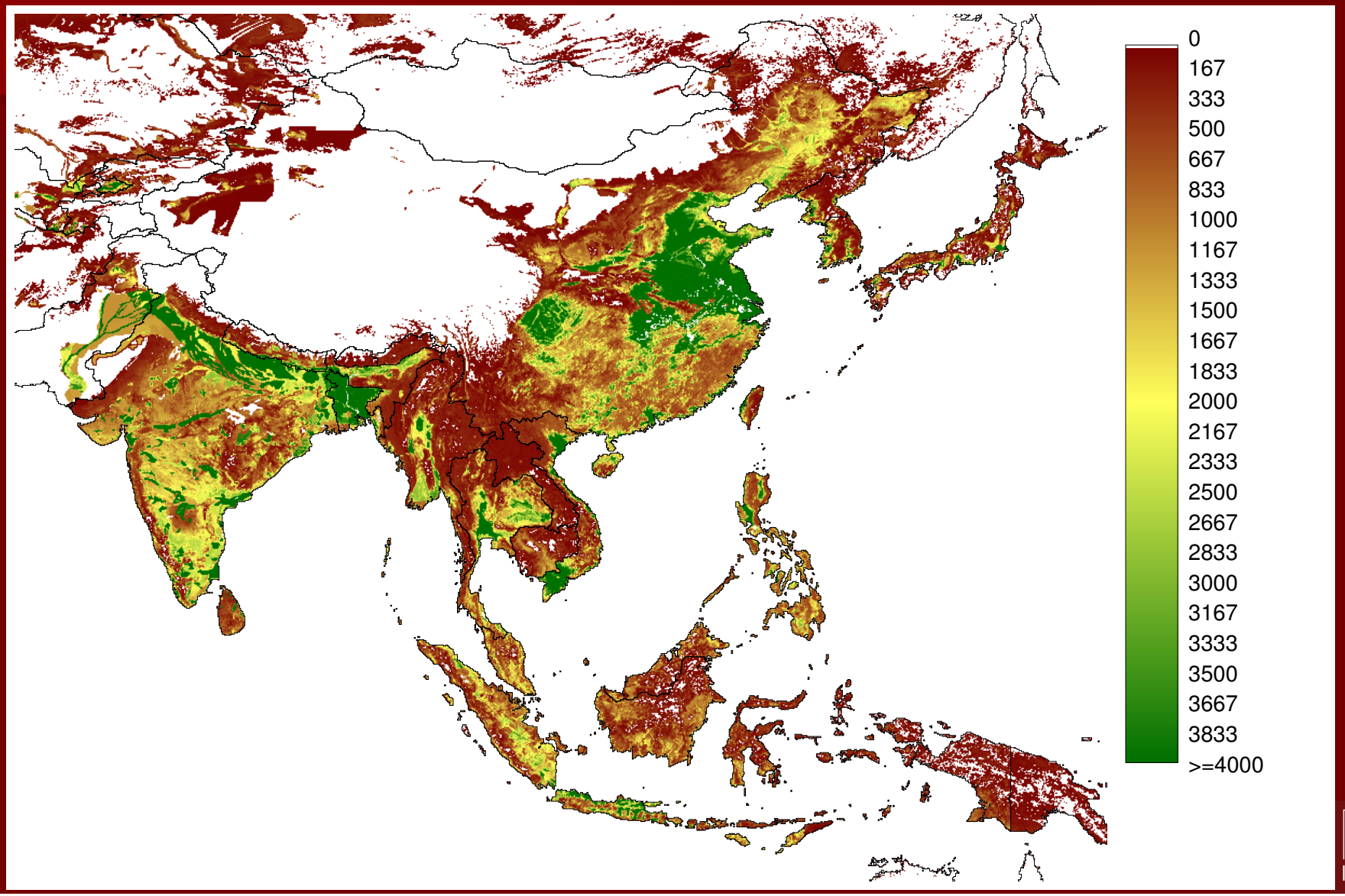
Down-scaling Results: Value of Agricultural Output per Grid-cell



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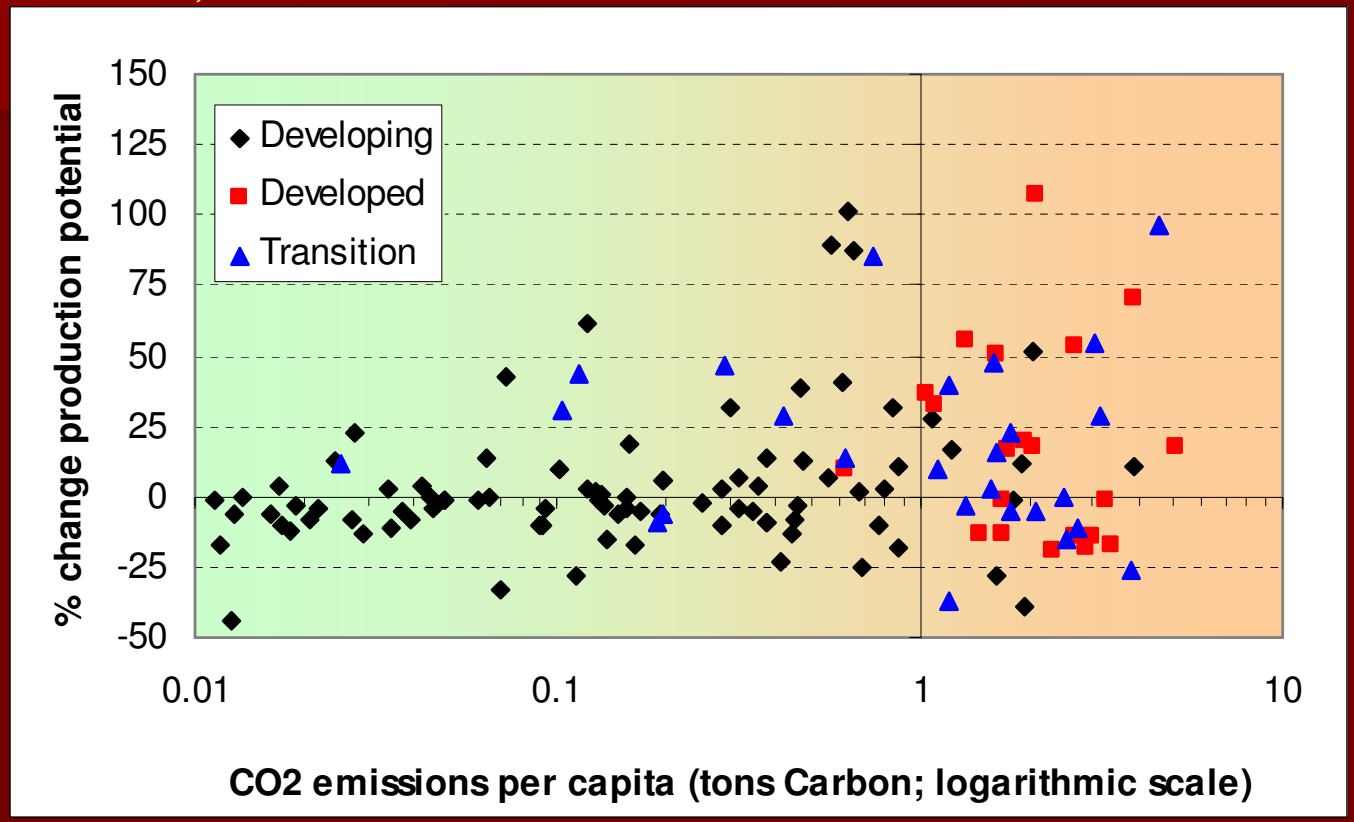
Climate Change Impacts and Carbon Dioxide Emissions

ECHAM4, 2080s



(Fairness and Equity?

Greenhouse gas emissions since 1950:

75% from developed countries, 25% from developing countries

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Agro-ecological Spatial Analysis

- **Assessment of environmental changes – water stress areas (rain-fed and irrigated), land scarce areas, pressures on forest areas, arid and semi arid areas**
- **Food crops, current and potential land and water resources, yield gap analysis**
- **Livestock production (pastoral, intensive and mixed) and environmental and health impacts**
- **Bio-energy and food crop competition**
- **Climate change agricultural adaptation and mitigation**

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Agroecological-socioeconomic Spatial Analysis

- International food system and prices;
- Global and regional impacts of crop failures in major producer and consumer regions: Food security implications
- Impacts of subsidy and trade reforms
- Impacts and costs of climate change-adaptation and mitigation

Rainfed Agriculture and Climate Change Mitigation

- Conserve forest areas to reduce CO2 emissions; also important with regard to protecting wetland areas, reducing flood risks
- Promote conservation tillage, agro-forestry, and rehabilitation of degraded crop and pasture land
- Reduce practices of "slash and Burn" especially in range land areas as well with regard to crop residue burning.
- Monitor seasonal variability and integrate rangeland and feedlots as well as livestock migration in response to seasonal climate changes on grazing availability and condition, especially in semi-arid rangelands where soil erosion and decreased recharge of local watering points and aquifers severely limit the productivity rangeland.
- Improvement of nutrition and genetics of ruminant livestock, storage and capture technologies for manure, and conversions of emissions into biogas.
- Ensure efficient use and application of fertilizers through for example, precision agriculture
- Adopting livestock production technologies that reduce GHG emissions

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Rainfed Agriculture & Climate Change Adaptation

- **Climate Change Research** : Systemic observation, monitoring and data gathering; building scientific capacity and establishing research networks; downscaling GCMs to RCMs, climate change and food security policy analysis
- **Agricultural Knowledge Systems:** Information communication networks; Inventory existing adaptation practices
- **Agricultural Sciences:** A systemic combination biological sciences, agro-ecology, social and economic sciences.
- **Agricultural Extension Services**: Promotion of moisture conserving technology in rainfed areas including conservation tillage; biological and chemical responses to potential climate change emergence of pests and diseases; drought management and supplementary irrigation systems; changing crop varieties and planting dates etc
- **Agricultural Marketing Services:** Disseminating market price information as well as timely weather information; crop insurance schemes; agro-industries to maximize value chain to farmers

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Intergenerational Sustainability

THANK YOU