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Impact of Climate Change on Agricultural Systems and Adaptation Responses

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Outline

- Drivers of Agricultural Growth and Food Security
- Scenario Modeling Methodology
- Climate Change Impacts
- Climate Change Adaptation Costs
- Conclusions and Policy Responses

Drivers of Agricultural Growth and Food Security

- Supply drivers
  - Climate change
  - Water and land scarcity
  - Investment in agricultural research
  - Science and technology policy
    - Discovery, development, delivery
    - Intellectual property rights, regulatory systems, extension

http://www.tribuneindia.com/2004/20040721/har.jpg

http://fbae.org/2009/FBAE/website/images/btcotton_rice.jpg

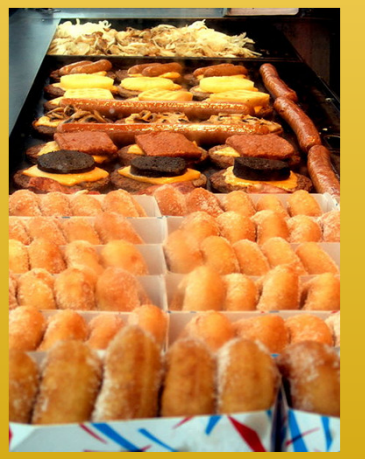
Drivers of Agricultural Growth and Food Security

- Demand drivers
  - Population growth: 9 billion people in 2050
  - Urbanization: 2008 = 50% urban; 2050 = 78%
  - Income growth
  - Oil prices
  - Biofuels and bioenergy
  - GHG mitigation and carbon sequestration
  - Conservation and biodiversity

http://www.government.nl/dsc?c=getobject&s=obj&objectid=101492

Drivers of Agricultural Growth and Food Security

- Rapid income growth and urbanization - effects on diets and patterns of agricultural production
  - Change in diets to convenience foods, fast foods
  - Increased consumption of fruits and vegetables
  - Higher food energy, more sugar, fats and oils
  - Rapid growth in meat consumption and demand for grains for feed
  - Half of growth in grain demand will be for livestock
  - Intense pressure on land and water (highly water-intensive diet)



http://en.wikipedia.org/wiki/File:Fast_food_(282678968).jpg

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Scenario Modeling Methodology

Climate Change Model Components

- GCM climate scenarios
  - Multiple GCM using IPCC SRES A1B scenario, downscaled temperature and rainfall
- SPAM
  - Spatial distribution of crops based on crop calendars, soil characteristics, climate of 20 most important crops
- DSSAT crop model
  - Biophysical crop response to temp and precipitation
- IMPACT
  - Global food supply demand model to 2050 with global hydrology and water simulation by river basin

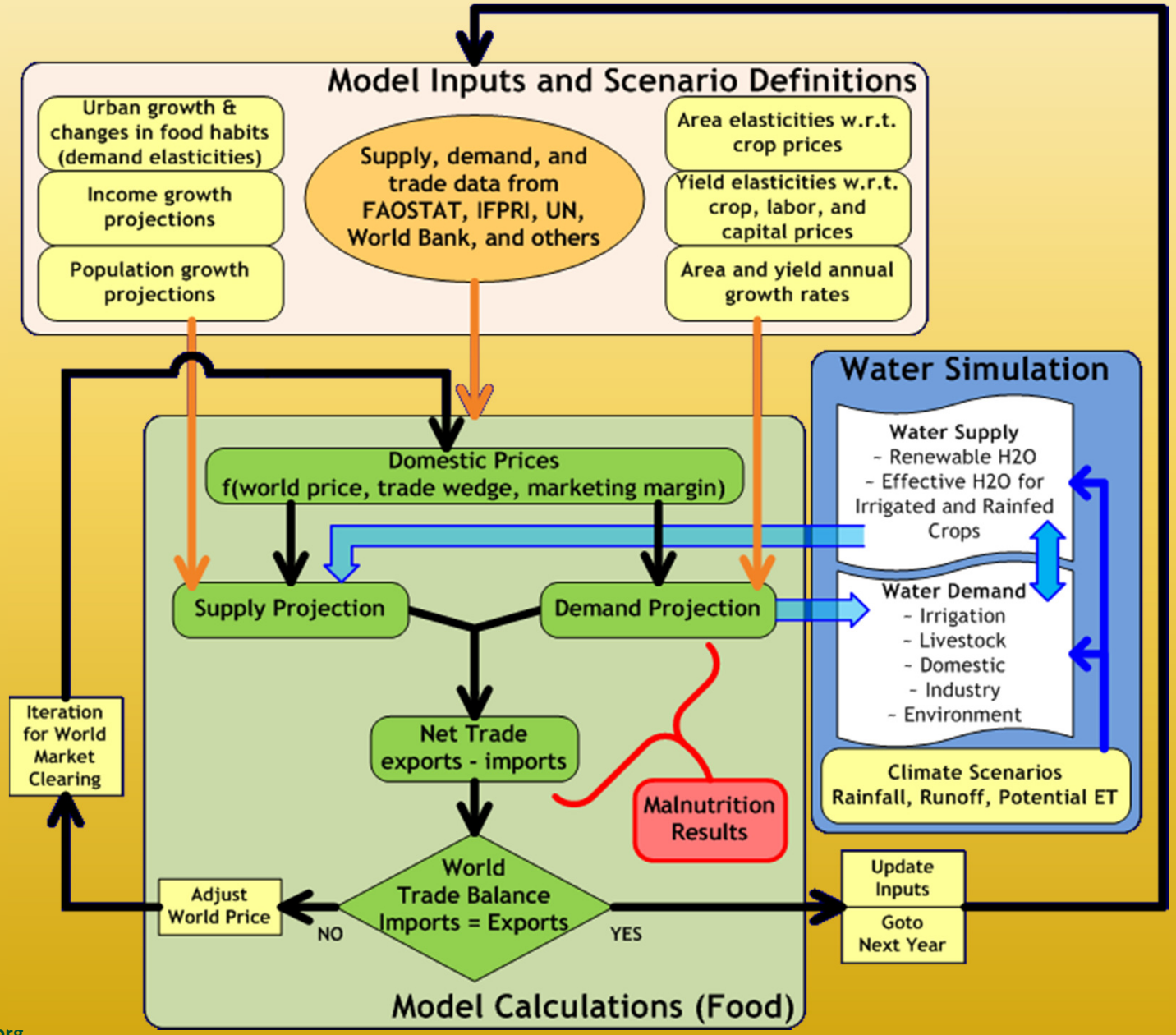
DSSAT Crop Models

- Simulate plant growth and crop yield by variety day-by-day, in response to
  - Temperature
  - Precipitation
  - Soil characteristics
  - Applied nitrogen
  - CO_2 fertilization
- DSSAT-based simulations at crop-specific locations (using local climate, soil and topographical attributes)
- Maize: 15,576 cells; Soybean: 9,930; Rice: 9,176; Wheat: 18,661

IMPACT Methodology

- Global, partial-equilibrium agricultural sector model with 46 agricultural commodities
- Links country or regional-level supply and demand through trade
- World food prices are determined annually at levels that clear international commodity markets
- Linked with a global hydrologic model to account for impacts of climate change on water resources
- Includes a Water Simulation model to account for water demand and availability for agriculture and other sectors
- Yield and area impacts from climate change incorporated through crop models for key crops (DSSAT)

Structure of IMPACT Model



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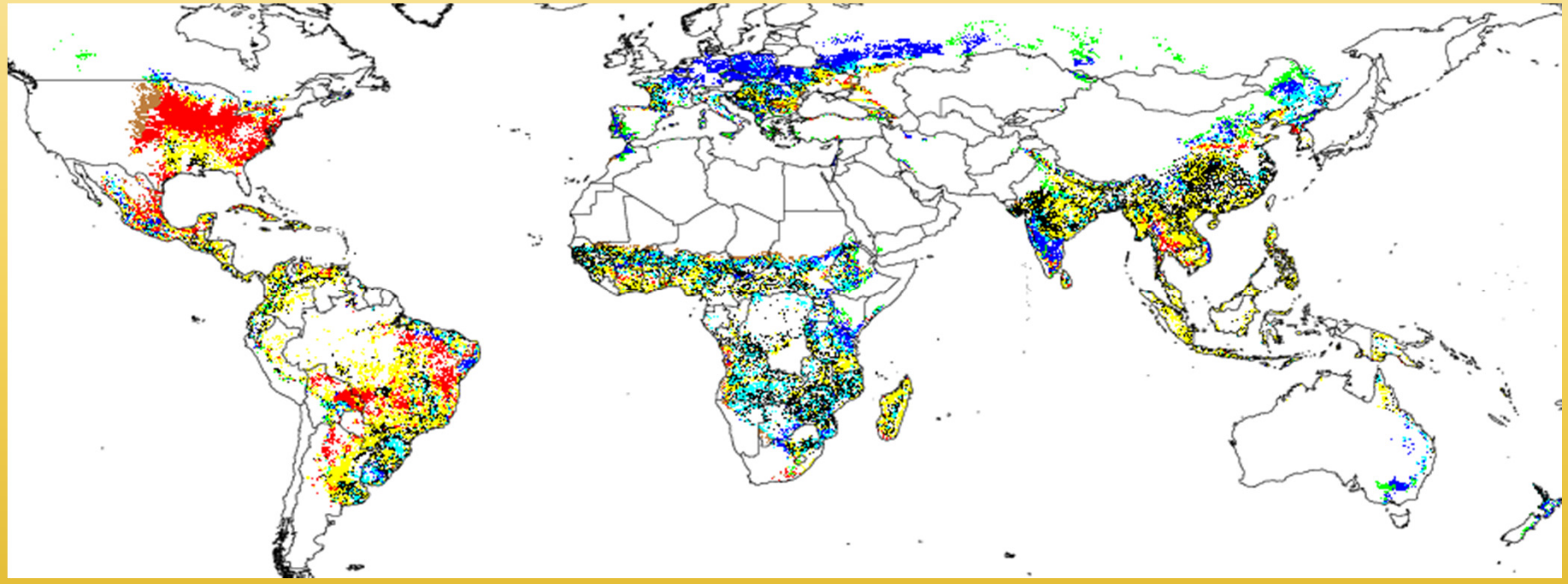
Climate Change Impacts

Rainfed Maize: Impact of climate change in 2050

(MIROC/A1B)



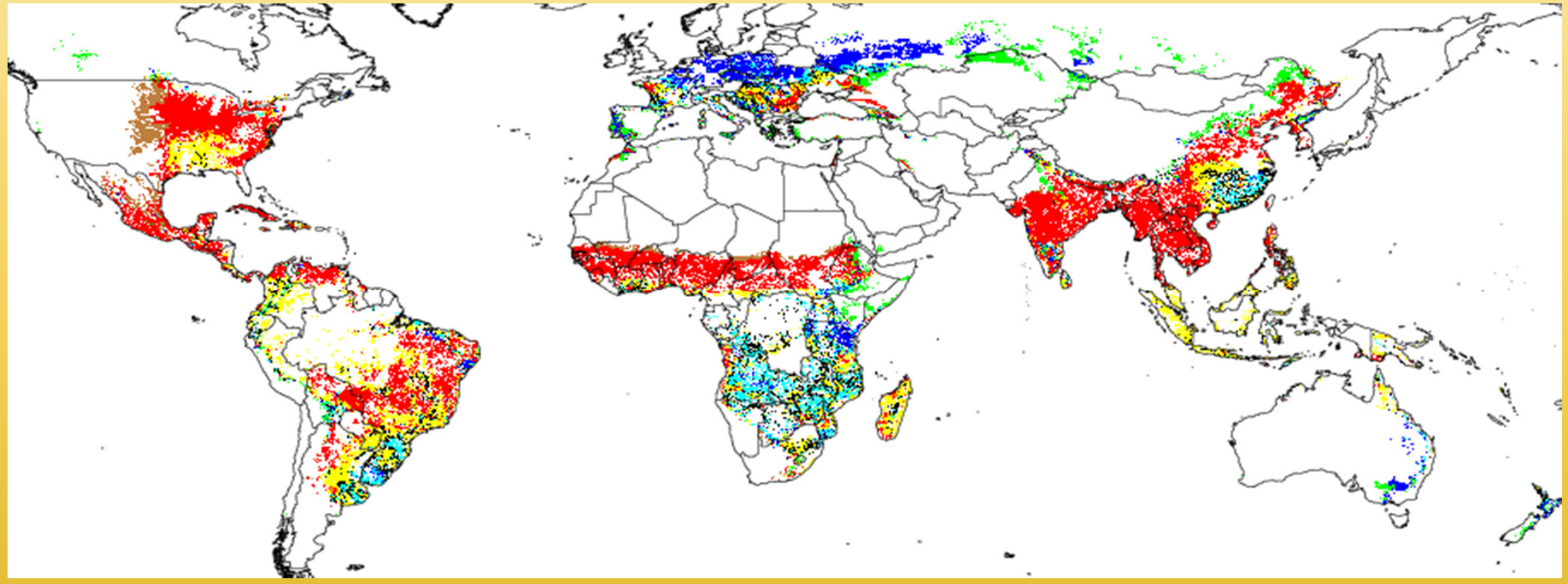
2000 old area lost
yield loss > 25% of 2000
yield loss 5–25%
yield change within 5%
yield gain 5–25%
yield gain > 25%
2050 new area gained

Overall production change in shown existing areas: -11.2%

Source: IFPRI IMPACT simulations

Rainfed Maize: Impact of climate change in 2080

(MIROC/A1B)



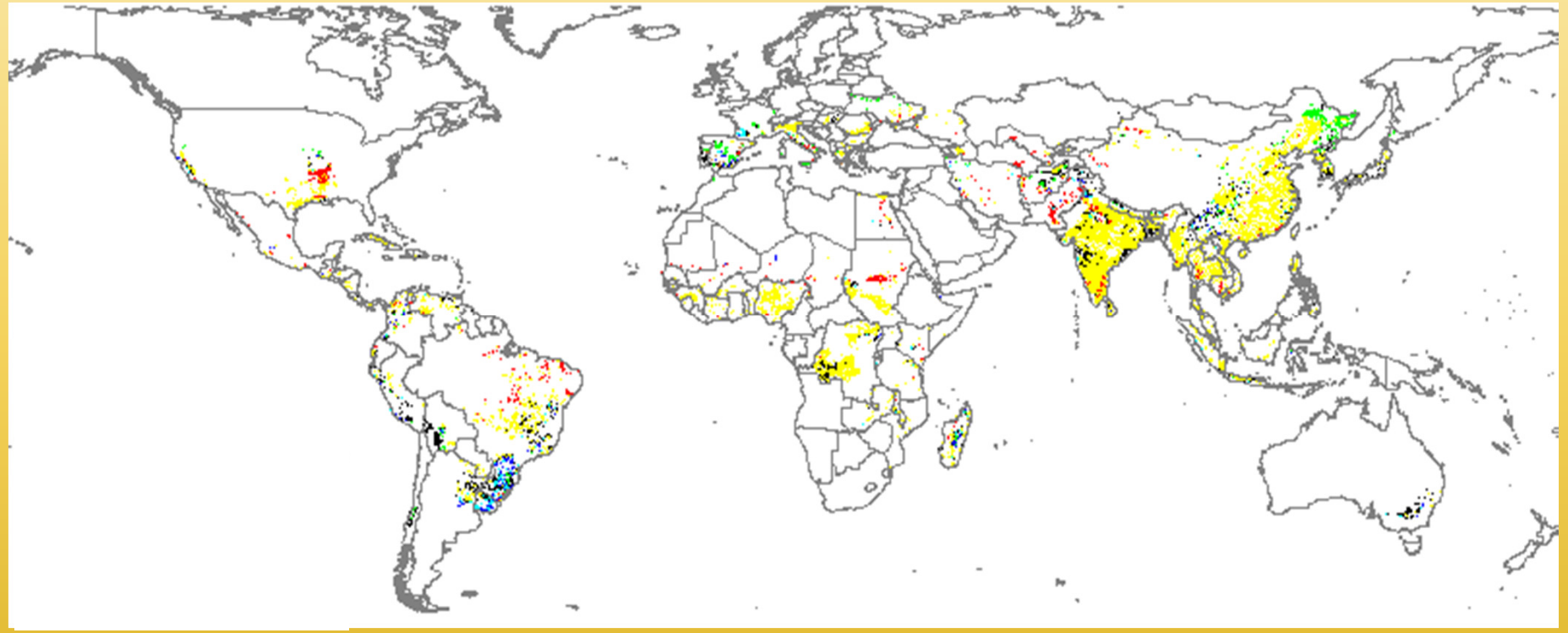
2000 old area lost
yield loss > 25% of 2000
yield loss 5–25%
yield change within 5%
yield gain 5–25%
yield gain > 25%
2050 new area gained

Overall production change in shown existing areas: -37.3%

Source: IFPRI IMPACT simulations

Irrigated Rice: Impact of Climate Change in 2050

(MIROC/A1B)



- 2000 old area lost
- yield loss > 25% of 2000
- yield loss 5–25%
- yield change within 5%
- yield gain 5–25%
- yield gain > 25%
- 2050 new area gained

Overall production change in shown existing areas: -10.5%

Source: IFPRI IMPACT simulations

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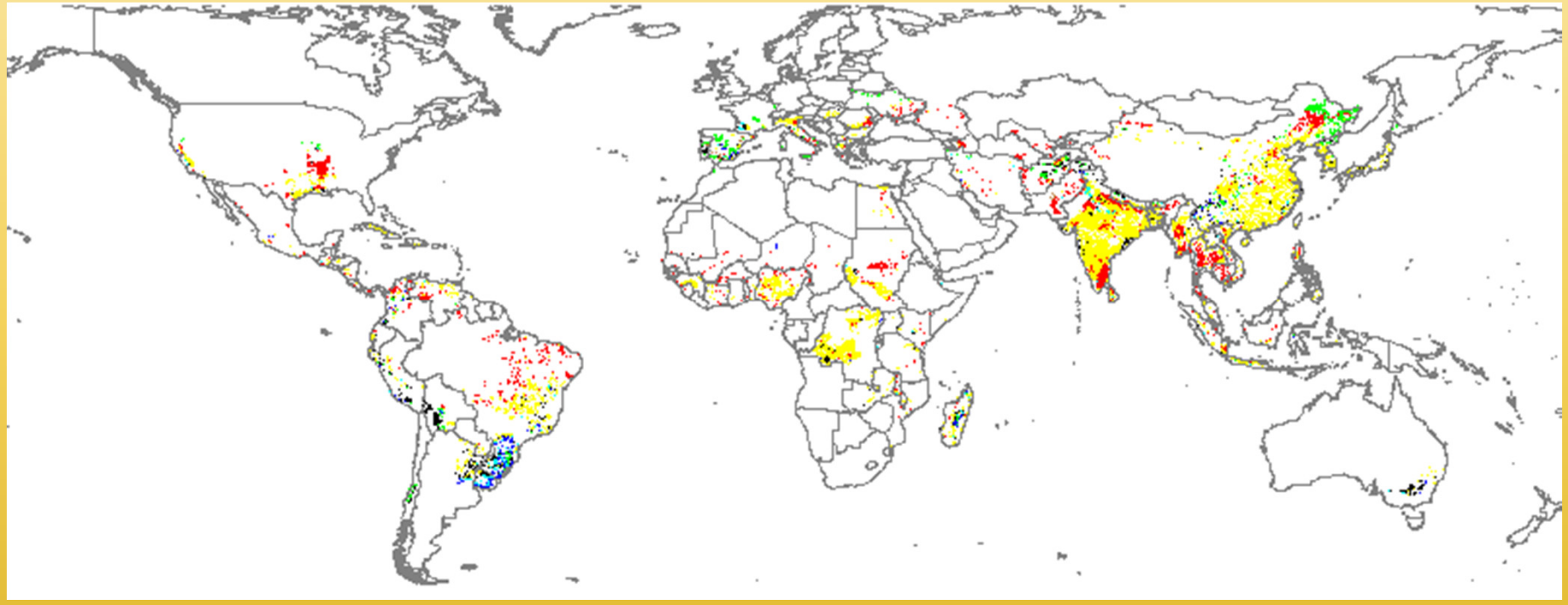
Irrigated Rice: Impact of Climate Change in 2080

(MIROC/A1B)



2000 old area lost
yield loss > 25% of 2000
yield loss 5–25%
yield change within 5%
yield gain 5–25%
yield gain > 25%
2050 new area gained

Overall production change in shown existing areas: -16.1 %

Source: IFPRI IMPACT simulations

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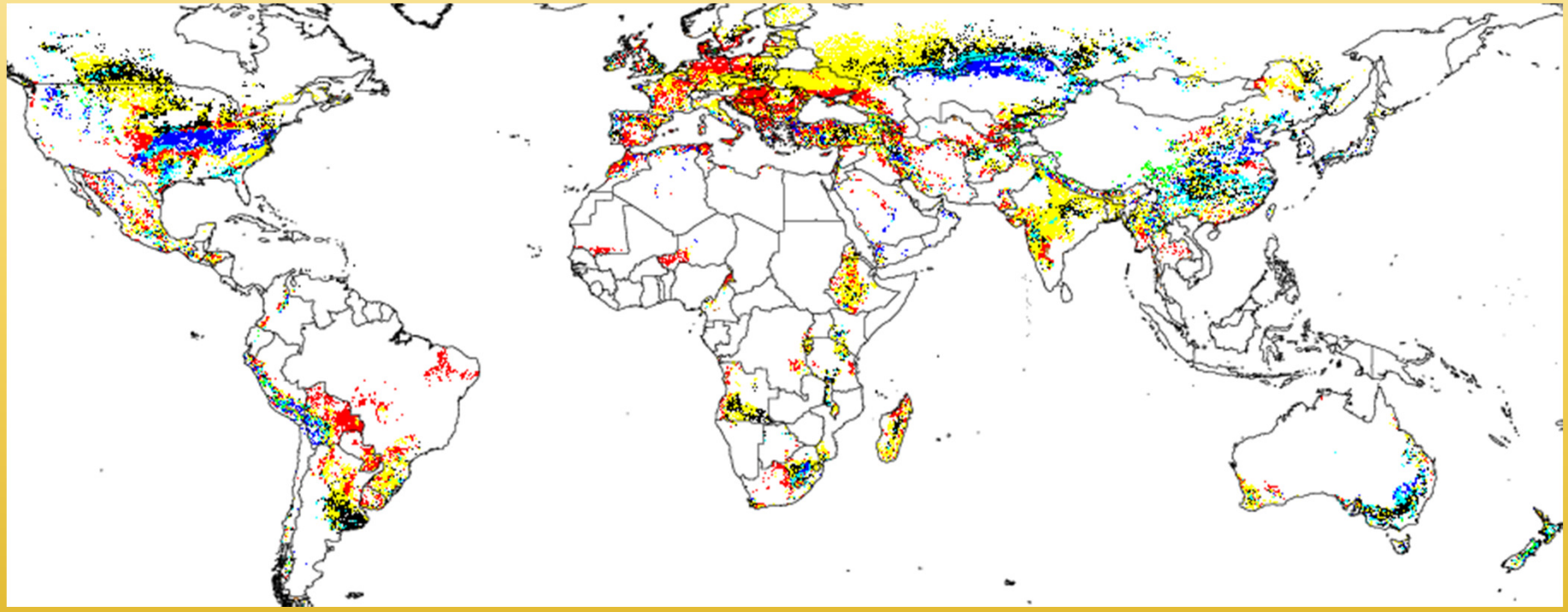
Rainfed Wheat: Impact of climate change in 2050

(MIROC/A1B)



2000 old area lost
yield loss > 25% of 2000
yield loss 5–25%
yield change within 5%
yield gain 5–25%
yield gain > 25%
2050 new area gained

Overall production change in shown existing areas: -8.1%

Source: IFPRI IMPACT simulations

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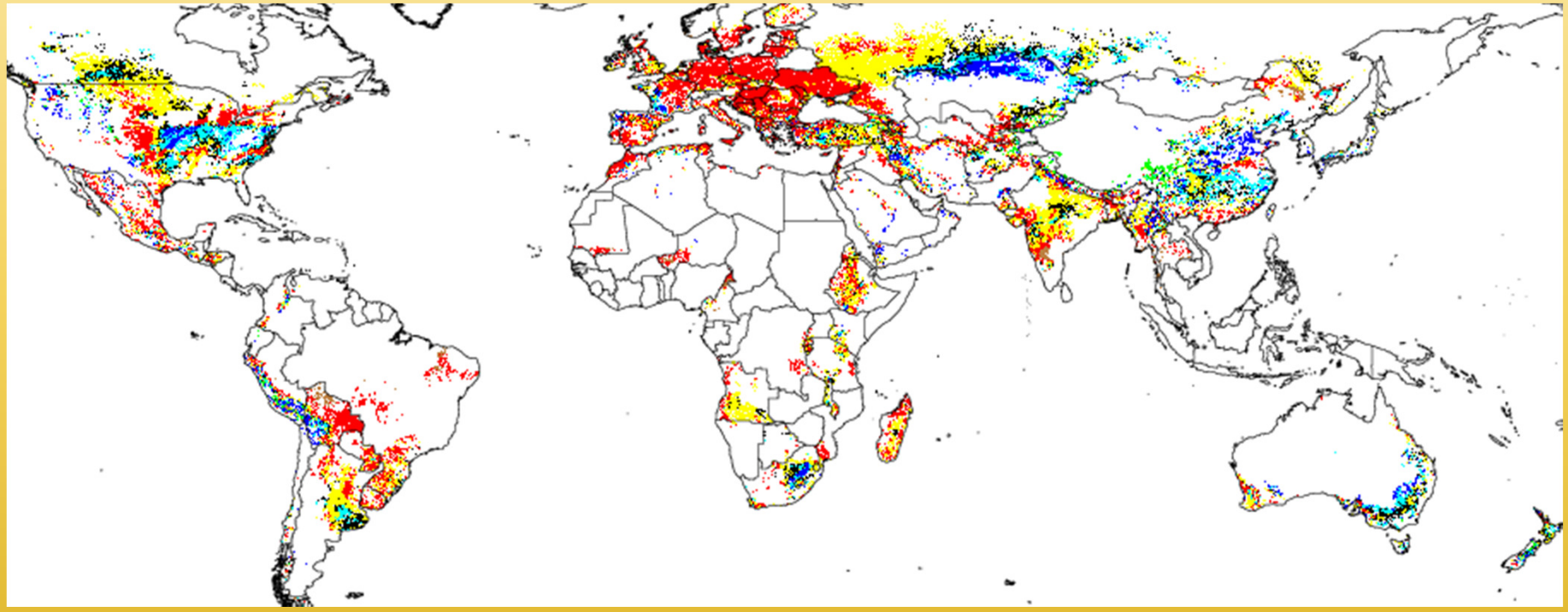
Rainfed Wheat: Impact of climate change in 2080

(MIROC/A1B)



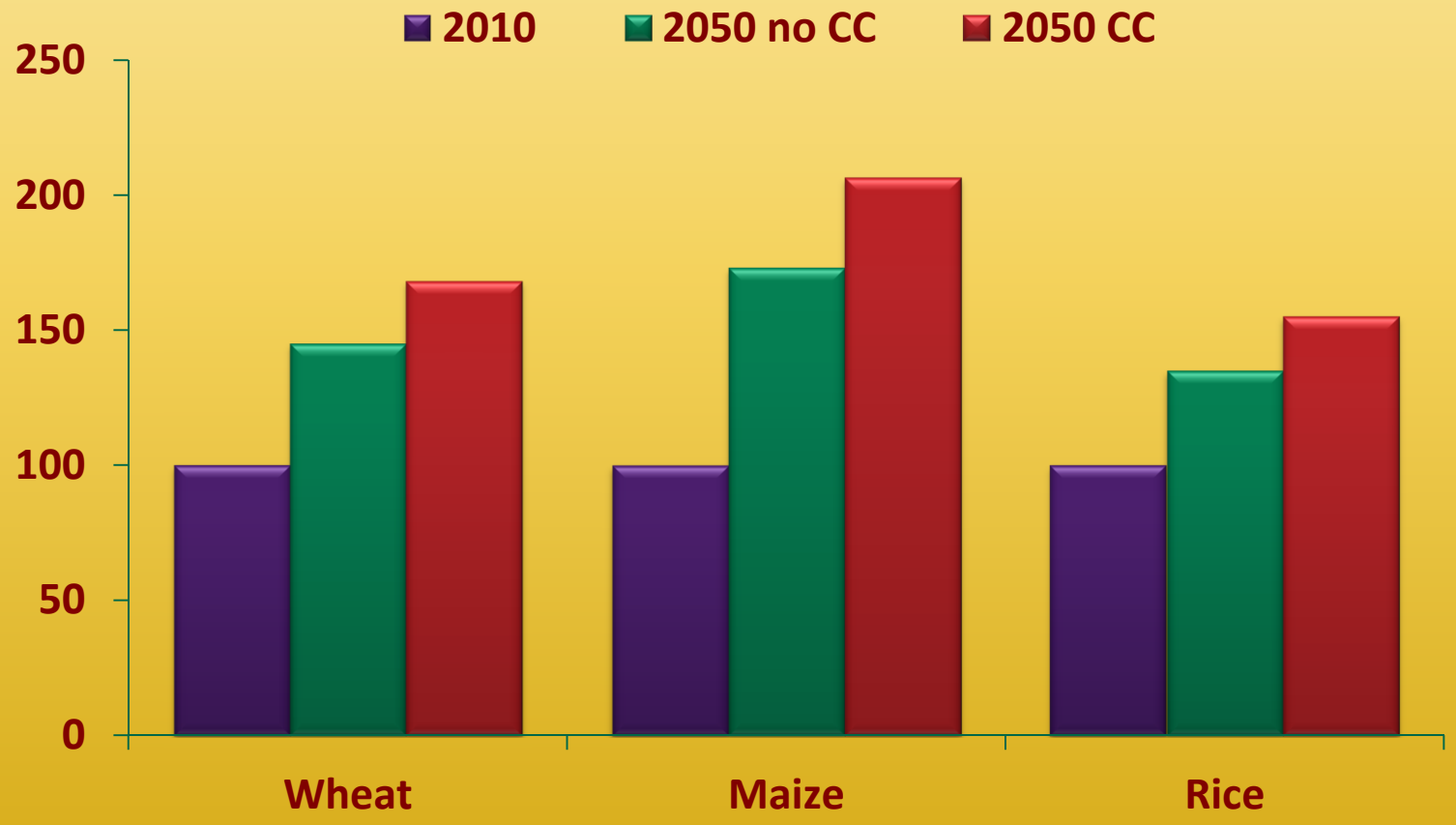
- 2000 old area lost
- yield loss > 25% of 2000
- yield loss 5–25%
- yield change within 5%
- yield gain 5–25%
- yield gain > 25%
- 2050 new area gained

Overall production change in shown existing areas: -15.5%

Source: IFPRI IMPACT simulations

Impact on International Food Prices (2010=100)

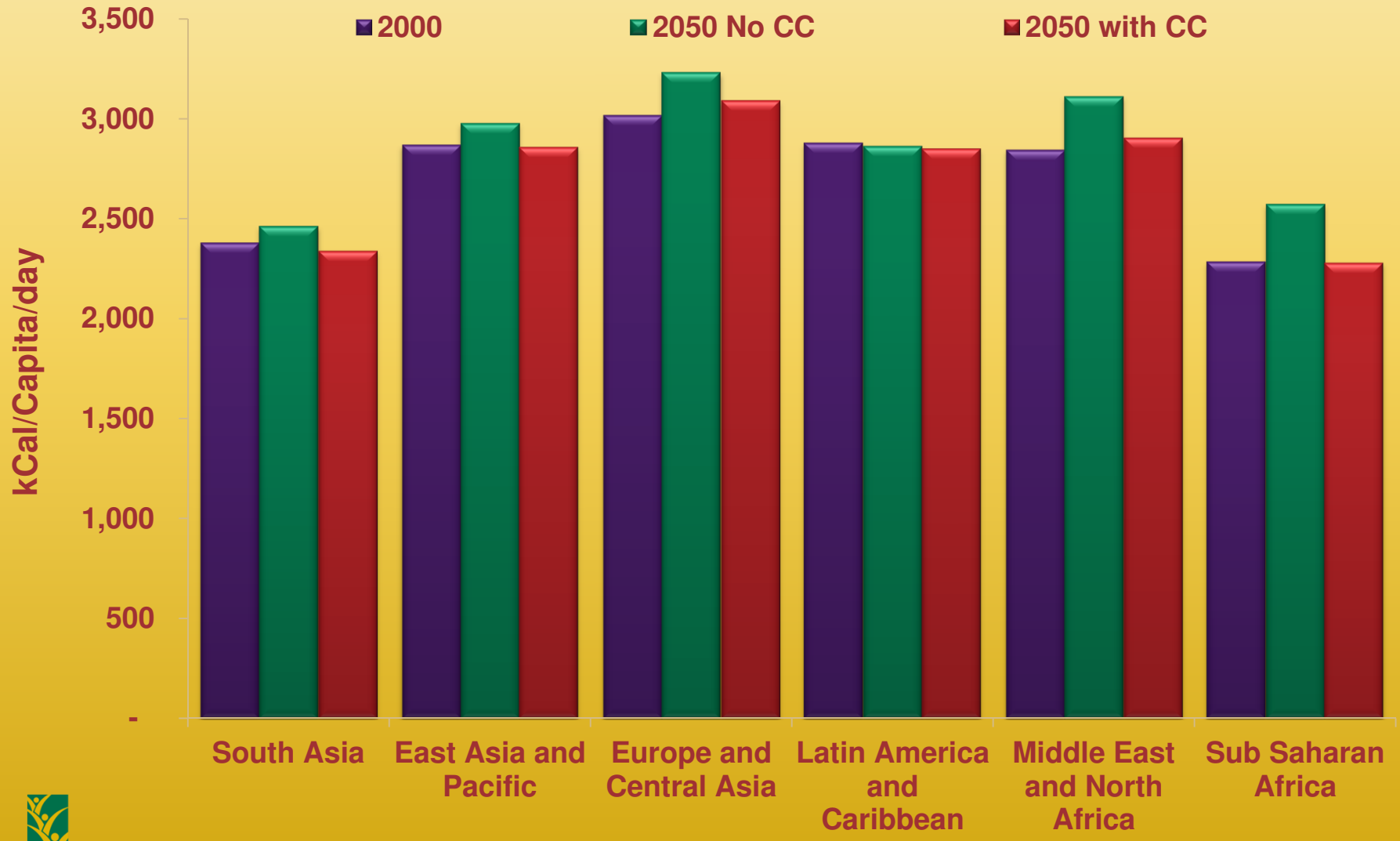
Average of four GCM, A1B, A2 ,B1, B2 Scenarios



Source: IFPRI IMPACT simulations

Impact on Calorie Consumption

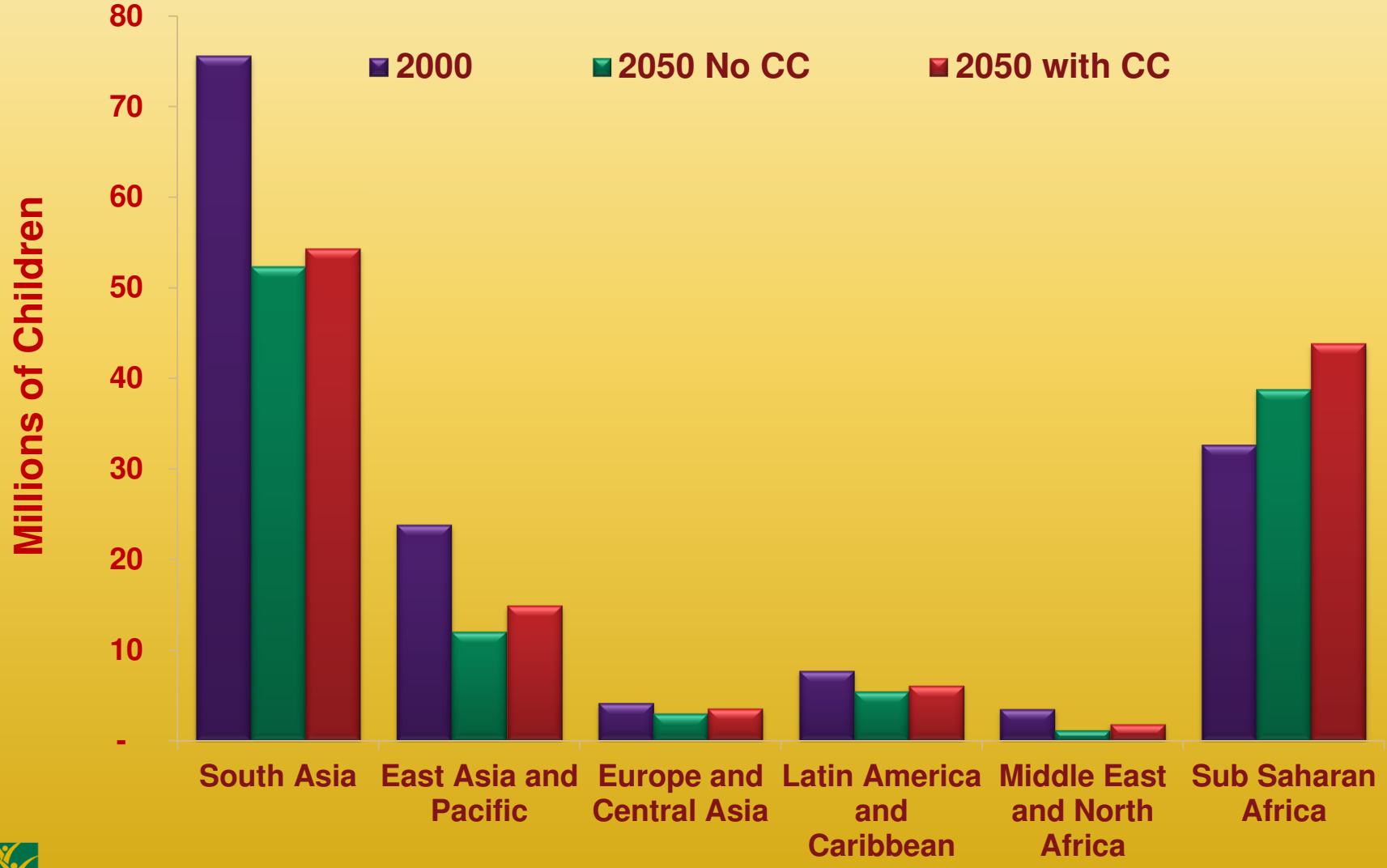
Average of 4 GCM and 4 scenarios = 12 % decline in developing countries



Source: IFPRI IMPACT simulations

Impact on Childhood Malnutrition

Average of 4 GCM and 4 scenarios = 10% increase in developing countries



Source: IFPRI IMPACT simulations

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Climate Change Adaptation Costs Estimated in IMPACT Model

Our Definition of Agricultural Adaptation

- Agricultural investments that reduce child malnutrition *with* climate change to the level *with no* climate change
- What types of investments considered?
  - Agricultural research
  - Irrigation expansion and efficiency improvements
  - Rural roads

Adaptation Costs are Large

- Required additional *annual* expenditure: $7.1-$7.3 billion
- Regional level
  - Sub-Saharan Africa - 40% of the total, mainly for rural roads
  - South Asia - US$1.5 billion, research and irrigation efficiency
  - Latin America and Caribbean - US$1.2 billion per year, research
  - East Asia and the Pacific - $1 billion per year, research and irrigation efficiency

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Conclusions and Policy Responses

Conclusions

- Climate change will have negative impacts on agricultural production and food security in developing countries
- Agriculture is critical for
  - Employment
  - Economic development
  - Food security
- Significant new expenditures required to reduce the adverse impacts of climate change

Conclusions

- Good agricultural development policy is good adaptation policy
- Climate change is a threat multiplier: requires higher investment to reach development goals
- Sustainable agricultural growth in hands of farmers reduces poverty and facilitates climate change adaptation and mitigation
- Greater investment needed in climate-sensitive traits and protection against climate variability and extremes

Key Adaptation Policies and Investments

- Breed crops for biotic and abiotic stresses→ agricultural productivity growth key to future food security under climate change
- Enhance water control
- Implement knowledge, information and risk-sharing approaches to support flexible farmer adaptation
- Support open trading regimes to share climate risk
- Use market-based approaches to manage water and environmental services combined with secure property rights

Key Adaptation Policies and Investments

- Reduce perverse agricultural subsidies that encourage overuse of inputs and higher carbon emissions
- Improve definition and protection of land and water property rights
- Recognize carbon as a global externality and value carbon through carbon trade

http://wokai.typepad.com/.a/6a00e54f957b1888330115704a4cca970b-500wi

Agricultural Productivity

- Increasing crop productivity: agricultural research, resource conserving management, and rural investment
  - Emphasis on crop and livestock breeding (including biotechnology) targeting abiotic and biotic stresses
  - Water harvesting, precision agriculture, minimum tillage, integrated soil fertility management, integrated pest management, reduction of post harvest losses
  - Rural infrastructure investment to improve access to markets, risk insurance, credit, inputs, mobile phone towers