MIT Global Change Forum XLII

Agriculture: Risks and Opportunities

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MIT Global Change Forum XLII

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a few main points

(1) agriculture is a complex system

(2) agriculture is rapidly changing due to technology and socioeconomic forces

(3) agriculture and environment—contributes to environmental change and is affected by it

Agriculture: Risks and Opportunities

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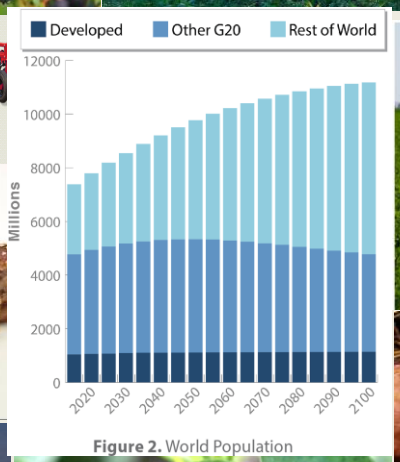
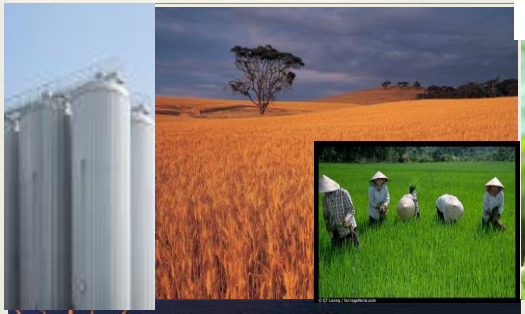
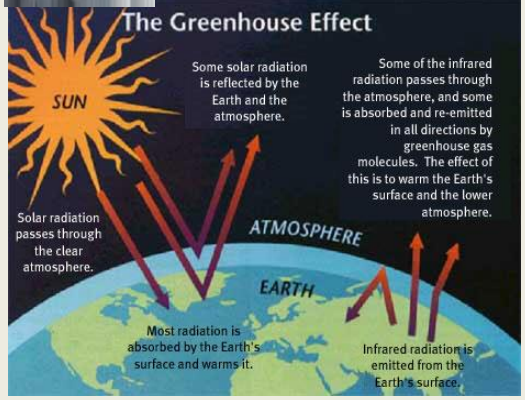
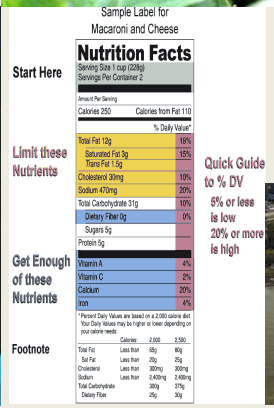
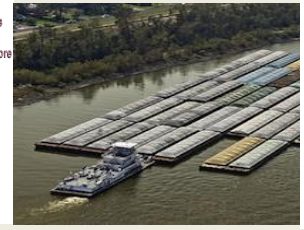


Figure 2. World Population









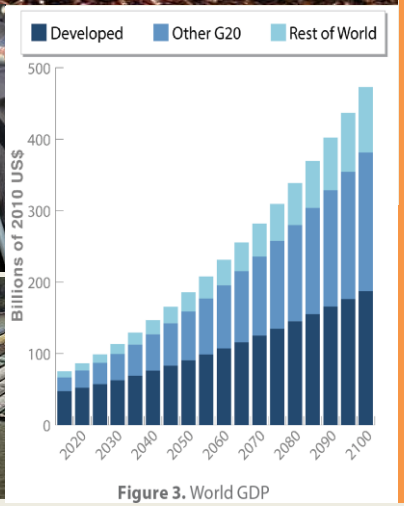


Figure 3. World GDP

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rapidly changing
growing demand

- 2050 global population, 9-10 b., from 7.3 b. in 2015 /yr
  - 13 years (1974-87) to go from 4 to 5b. 1.7%
  - 12 years (1987-99) to go from 5 to 6b. 1.5%
  - 11 - 12 years (1999-2011 or 2012) from 6 to 7b. 1.3%
  - 12.66 years per b. added if 7 to 10b. (2012-2050). 0.9%
- We expect the world to be wealthier.
  - World GDP up more than 2x; per capita 1.7x
  - Developed, GDP up 1.7x, little population growth
  - Other G20, GDP up 2.9x, per capita 2.6x
  - Rest of World, GDP up 2.7x, per capita 1.7x—continuing population growth

rapidly changing

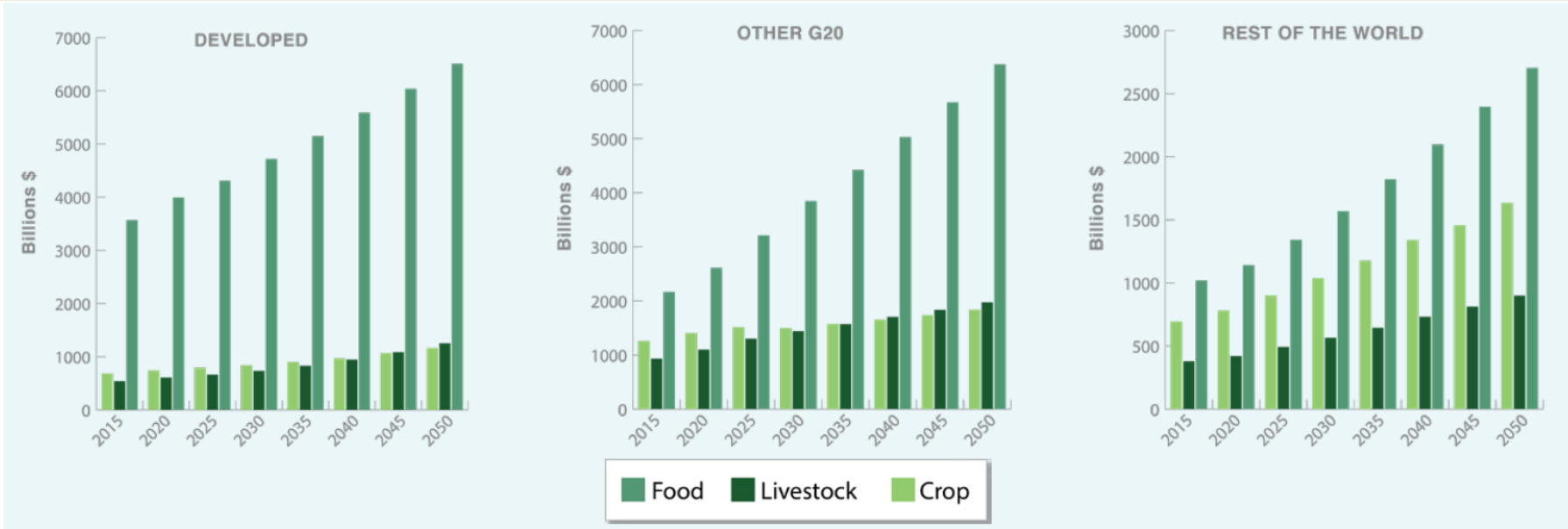
3 (necessary) transformations especially in poorer countries

- structural transformation
  - Declining share of agriculture in the economy
  - Rural-urban migration
  - Less labor in agriculture, demand pull or supply push?
- value chain transformation
  - Initially from state and parastatal organizations to fragmented small and medium private enterprises
  - Privatization has drawn in more foreign direct investment
  - More processing, retail, focus on food safety/quality, increasing diversity and changes in diet.
- technology transformation
  - sensors, satellite mapping, precision agriculture
  - robotics, autonomous vehicles
  - genetic engineering

2018 Food, Water, Energy, and Climate Outlook

rapidly changing

Food, livestock, crop production changes for 3 regions



Observations:

(1) value added growth—food demand increase compared with basic commodity increase: Developed, other G20, ROW differences

(2) More rapid growth of livestock

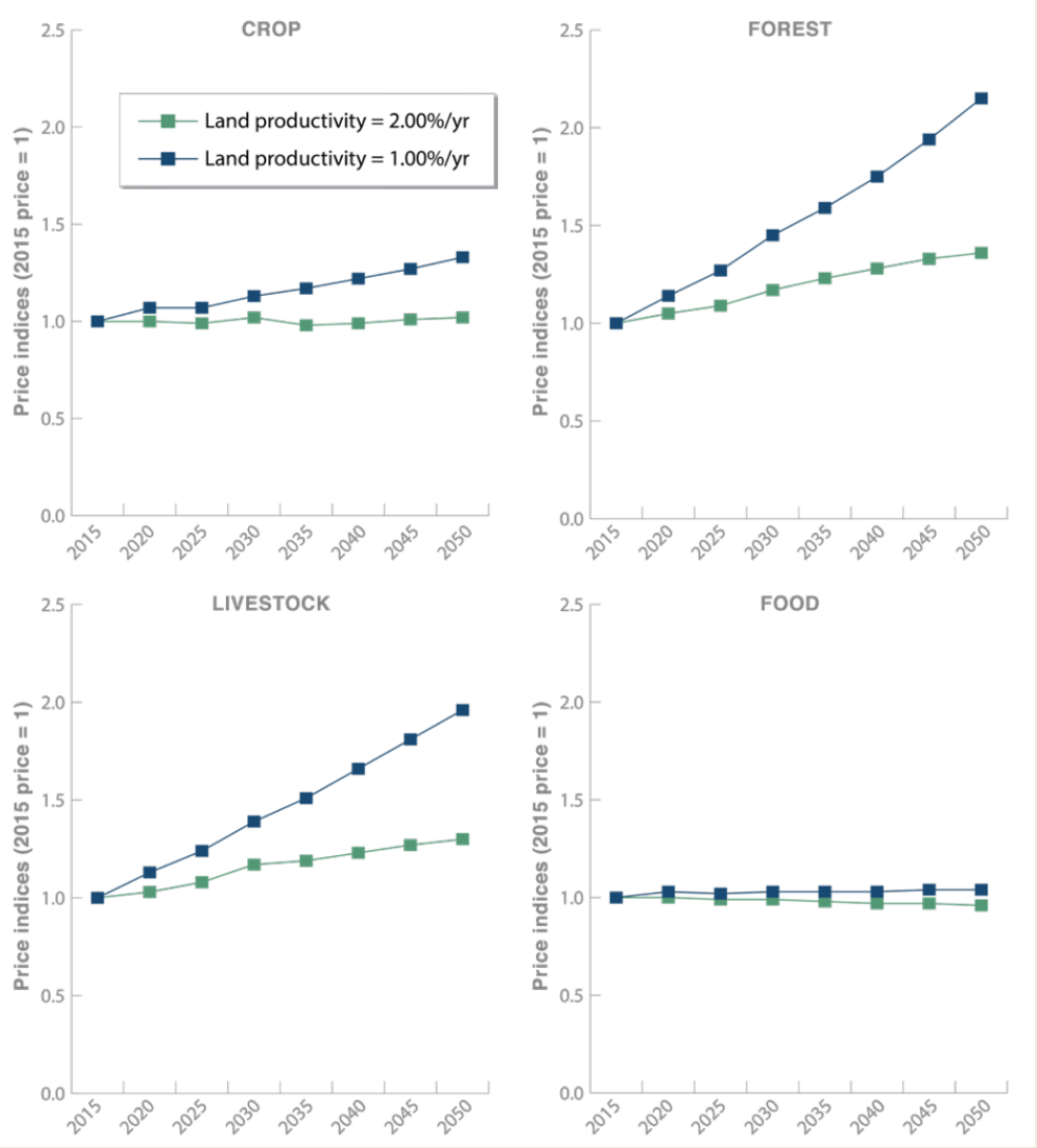
(3) ROW still rapid growth in basic commodity production

(4) Underlying assumption is income elasticity of crop demand is near zero, but continued growth in crop demand for livestock feed.

2018 Food, Water, Energy, and Climate Outlook

rapidly changing

commodity prices trends depends on productivity increases (i.e. technological change that increase yield.)



Observations:

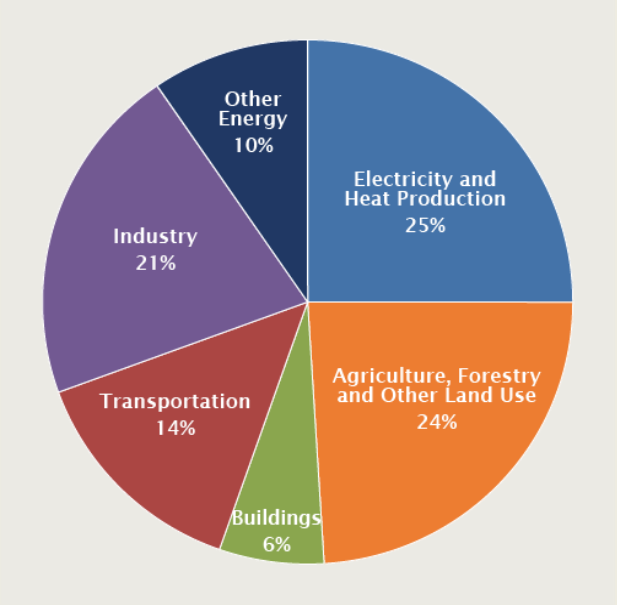
(1) Food prices show relatively small effect of higher commodity prices-–small cost share in final food costs.

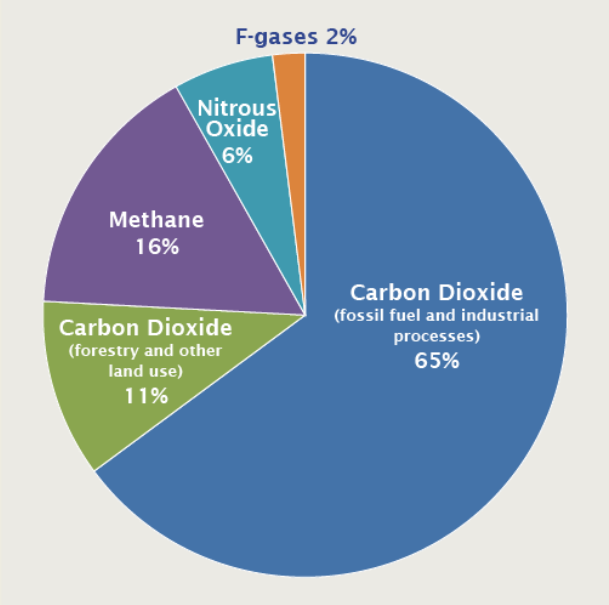
(2) More rapid growth of livestock prices because of diet shift toward meat as incomes grow.

2018 Food, Water, Energy, and Climate Outlook

it contributes to environmental change

- Agriculture (including forestry) & land use globally estimated to account for 24% of GHG emissions (but land sequestration offsets an estimated 1/5)
  - ~85% of nitrous oxide-largely from fertilizers
  - ~50% of methane—rice, ruminants, manure mgmt.





in our projections we find that broad pricing of GHGs results in higher cost agriculture—and hence rising commodity prices—reflected in previous price projections. pricing of carbon in land can have larger effects on commodity prices.

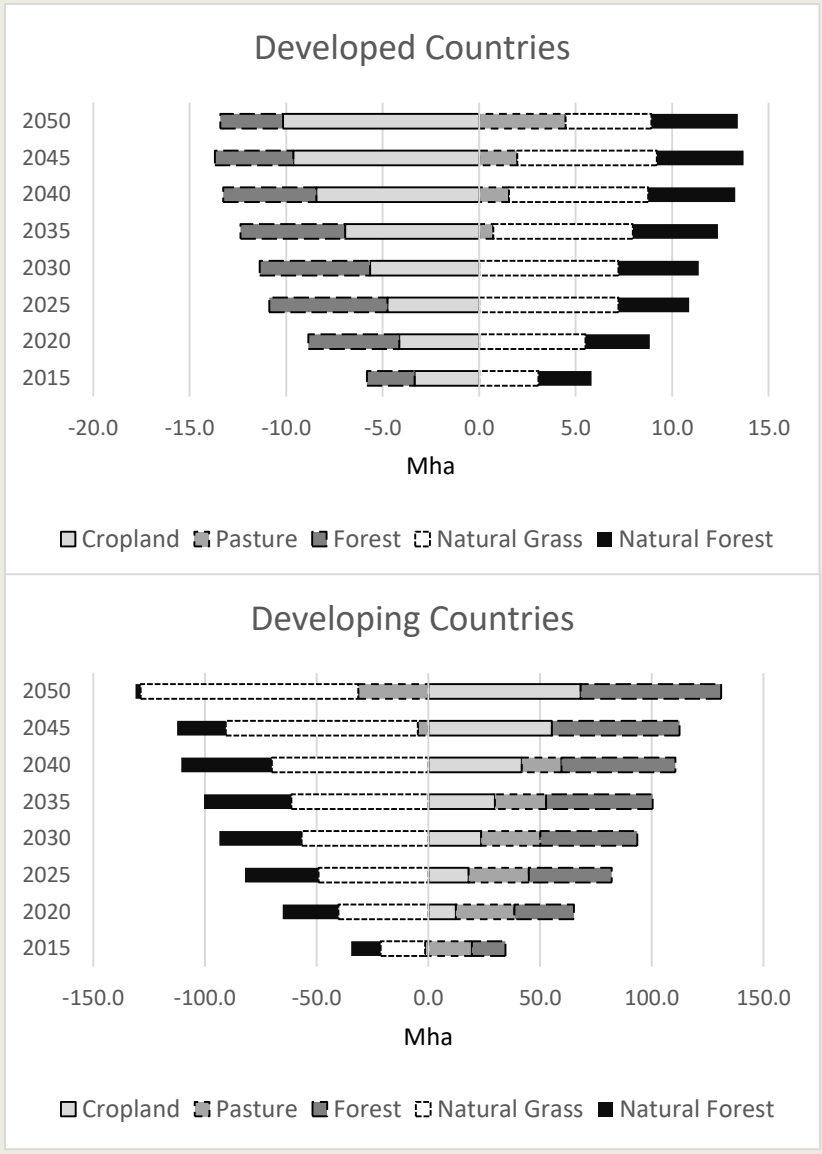
it contributes to environmental change

Resource competition: Land

With continued yield increases pressure on land for crop and livestock production does not create strong pressures on land, more reforestation in developed with deforestation in developing countries.

Table 5. Global land use, Mha.

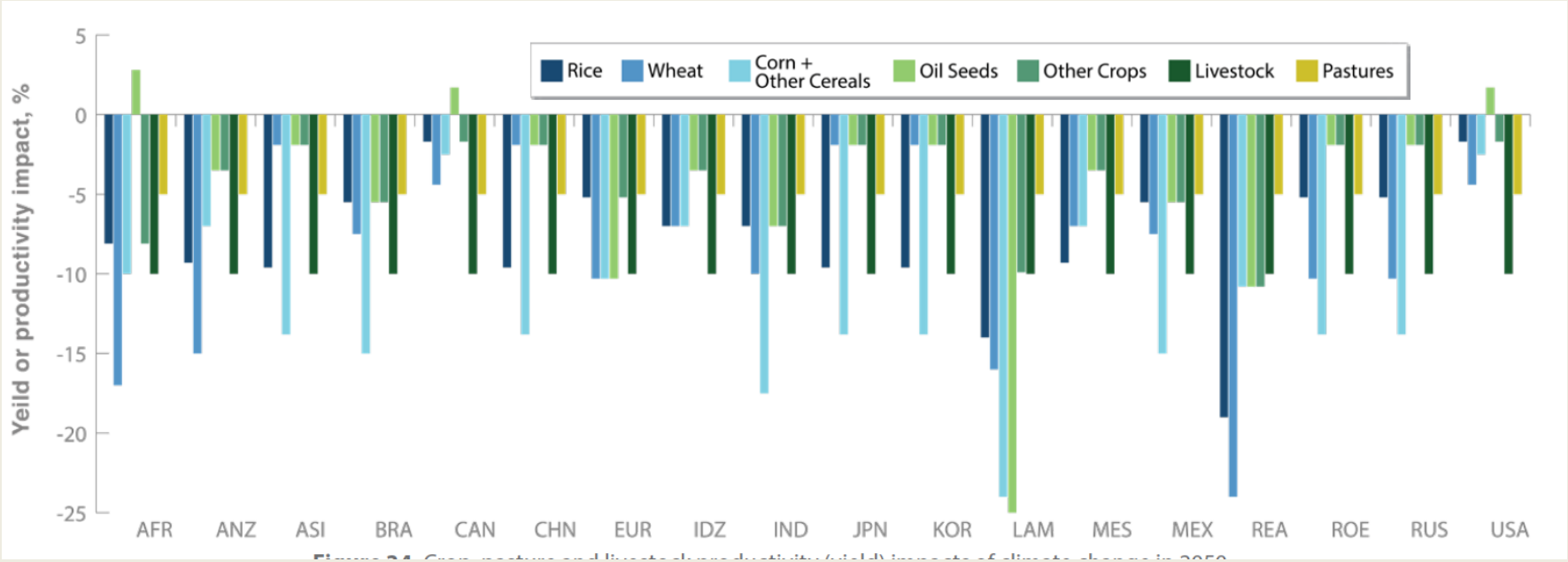
	Cropland	Pasture	Forest	Natural Grass	Natural Forest
2010	1555	2822	335	2028	3389
2015	1551	2841	347	2011	3378
2020	1564	2848	357	1993	3367
2025	1569	2849	366	1986	3359
2030	1573	2848	372	1979	3356
2035	1578	2846	377	1974	3354
2040	1589	2841	381	1965	3353
2045	1601	2819	388	1949	3371
2050	1613	2795	394	1935	3391



Gurgel, A. et al. (2016): in The WSPC Reference on Natural Resources and Environmental Policy in the Era of Global Change: V. 3: Bryant and A. Dinar (eds.), World Scientific

its affected by environmental change

yield effects by region and commodity after the IPCC AR-5



(1) "Median" estimates—ranges are very wide.
(2) IPCC included only major crops—we extended to other crops and livestock.
(3) Northern temperate regions (USA, CAN, CHN, RUS) less negatively affected; tropical regions (BRA, REA, LAM, AFR) more negatively affected.

2018 Food, Water, Energy, and Climate Outlook

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If we see yield effects like those projected by the IPCC how does it affect the outlook through 2050

Further price increase- generally less than 10% for crops, 25% or more for livestock, few percent for food (far right).

Terms of trade turn toward Northern Temperate (Developed regions) with production increases for most crops even though yield effects negative.

Price increases in livestock somewhat counter trend toward more livestock production.

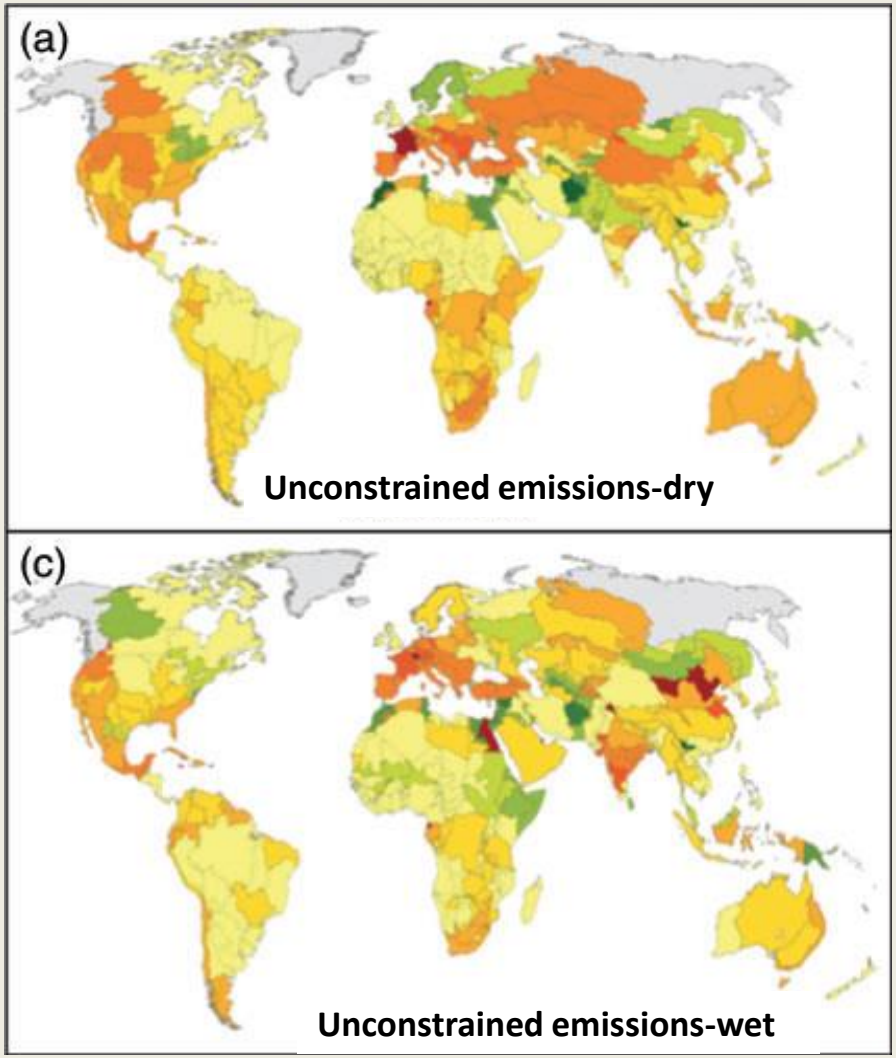
Further implications for land use change.

Table 3. Impacts from yield shocks on agricultural production, welfare, land-use areas and carbon emissions in 2050

% Change in Output	Developed	Other G20	Rest of the World	Total
Rice	2.1	-2.5	-6.4	-3.2
Wheat	1.3	-2.4	-3.7	-2.0
Corn & Other Cereals	3.7	-3.5	-2.1	-0.9
Oil Seeds	2.8	-1.7	-7.6	-2.1
Sugar Cane & Beet	0.1	-2.4	-3.5	-2.6
Vegetables & Fruits	0.8	-2.5	-1.8	-2.0
Fiber Plants	-1.2	-3.3	-0.8	-2.1
Other crops	1.7	-2.1	-3.5	-1.4
Cattle & Ruminants	-2.9	-4.4	-5.8	-4.4
Chicken & Pork	0.0	-6.1	-5.3	-5.2
Other livestock products	-1.2	-5.2	-5.1	-4.5
Forestry	1.2	-0.5	-11.8	-2.3
Food	0.6	-2.4	-3.1	-1.4
Welfare	-0.1	-1.6	-1.3	-0.7

its affected by environmental change still to consider—water availability

Climate increases irrigation water requirements (2050's compared with 2010's) in most regions…higher temperatures increase evapotranspiration. A few areas where precipitation increases more, reducing irrigation water needs.

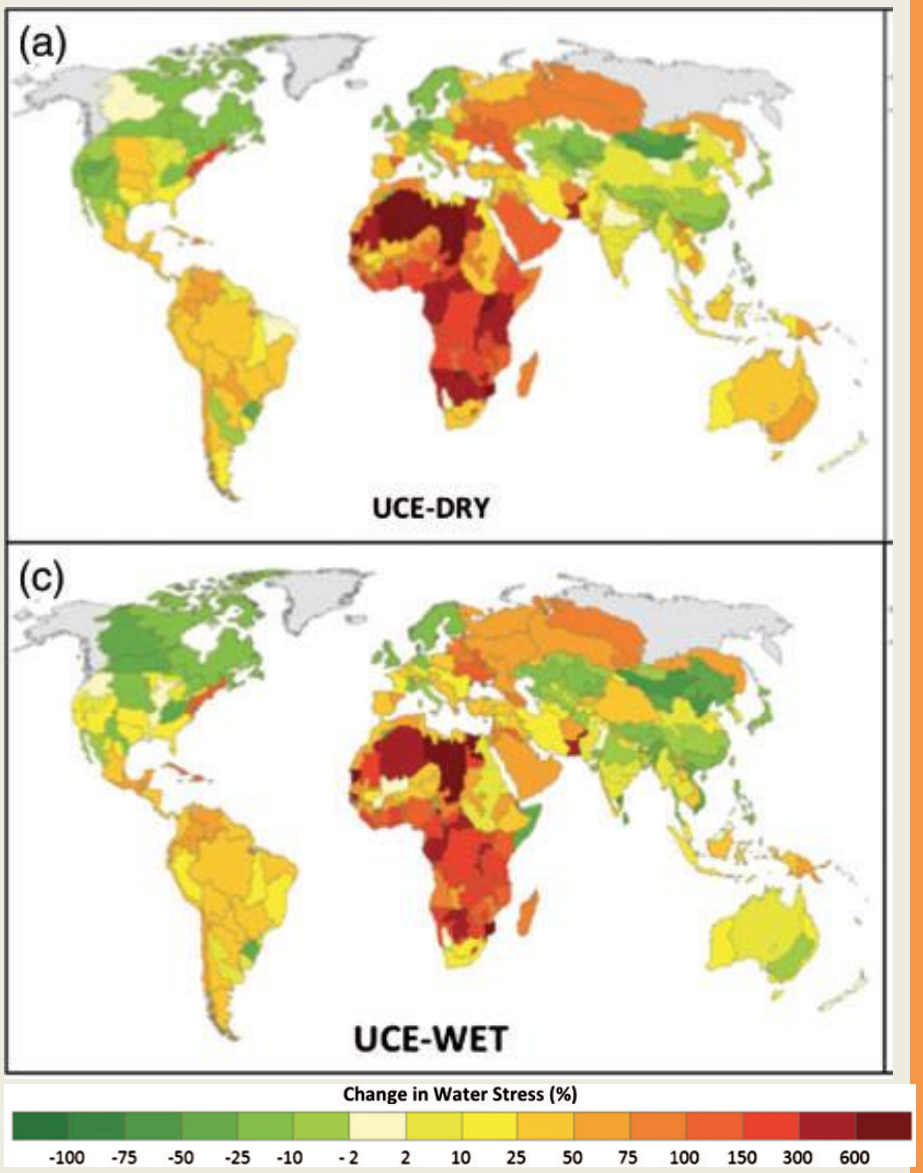


Schlosser, C.A. et al (2014), *Earth's Future*, 2(8): 341-361

its affected by environmental change

water availability for irrigation strongly affected by competing uses

Big increases in water stress (2050's compared with 2010's) due to irrigation requirements combined with growth in population and economic activity, and changing supply.



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prediction challenges

- Speed, scope and geographic extent of agriculture's 3 transformations
- Climate and environmental impacts on crops
  - Improve performance of crop models—better characterized management practices
  - resolve which crops are likely to grow where—link to economics
  - link to water resources/irrigation
- multiple stresses—soils, ozone, CO_2, haze, nitrogen deposition
- climate impacts beyond major crops
  - perennials, vegetables, tree crops
  - pests
  - supply chain disruption
  - food/crop quality-nutrition
- interaction of GHG reduction and climate impacts
- "Actionable" forecasts for adaptation