Effect of Future Climate on Water and Agriculture in Egypt

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This study was funded by USAID.

Washington, D.C. and Cairo Egypt | July 21, 2020

Introduction: Climate Change and Agriculture in Egypt

- Agricultural sector represent 11.4% of GDP and 21.1% of employment (CAPMAS)
- <90% of food production from irrigation
- Climate’s impact on agriculture: heat stress and potentially water stress
- CMIP6: the latest climate models have just been released
    - Not all are available for modeling: 8 of 100
- Possibly the first study of the impact of climate on the agricultural sector of Egypt using the latest climate models

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Precipitation, Temperature, and PET baseline and future, in cropped areas of Egypt

	1970-2000	Change from baseline, 1970-2000 to 2040-2060		
Season	Baseline	Min	Med	Max
Mean daily maximum temperature, ^{0}C				
JFM	21.1	1.8	2.1	4.0
AMJ	31.3	2.3	2.7	3.1
JAS	33.6	3.0	3.2	4.2
OND	25.3	2.3	2.5	4.1
Annual	27.8	2.4	2.6	3.9
Mean daily minimum temperature, ^{0}C				
JFM	8.4	1.8	2.0	3.7
AMJ	17.1	2.2	2.5	3.5
JAS	21.4	2.9	3.2	4.5
OND	13.0	2.4	2.7	4.2
Annual	15.0	2.4	2.6	4.0

	1970-2000	Change from baseline, 1970-2000 to 2040-2060		
Season	Baseline	Min	Med	Max
Rainfall, millimeters				
JFM	25	-2	-1	0
AMJ	3	0	0	0
JAS	0	0	0	0
OND	21	-2	-1	0
Annual	49	-4	-1	-1
Potential Evapotranspiration, millimeters				
JFM	178	10	13	27
AMJ	419	24	29	35
JAS	397	25	30	35
OND	169	6	8	17
Annual	1,164	72	85	97

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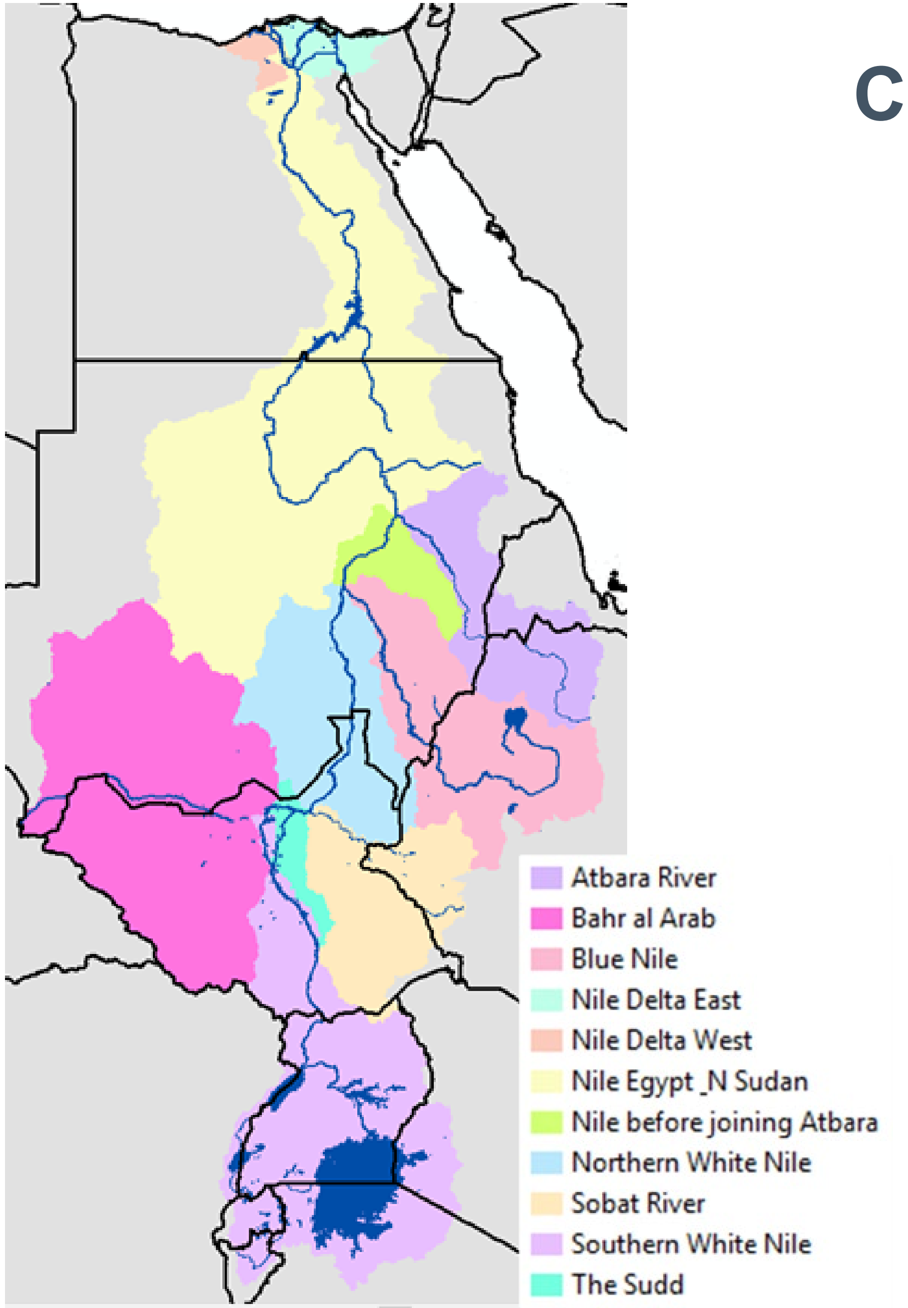

Changes in Runoff in Sub-basins of the Nile due to Climate Change

	Cubic kilometers			
	1970-2000	Change from baseline, 1970-2000 to 2040-2060		
Sub-Basin	Base	Min	Med	Max
Atbara River	30.1	3.9	17.2	41.3
Blue Nile	143.0	22.3	37.3	122.9
Main Nile in Sudan	1.9	0.2	1.6	4.0
Northern White Nile	28.3	2.8	13.6	23.1
Sobat River	64.4	5.1	9.7	94.8
Subtotal below The Sudd	267.9	39.0	79.0	216.0
The Sudd and above	349.8	-2.3	64.2	286.3

Projected Yield Changes from Climate Change, 2020-2050

Crop	Av. area harvested in 2004-06 (hectares)	Percent change in yield		
		Mini-mum	Median	Maxi-mum
Wheat	857,965	3%	7%	8%
Maize	694,140	-23%	-17%	-15%
Rice	544,881	-17%	-7%	-4%
Sorghum	130,936	-17%	-13%	-12%
Tomatoes	320,808	-17%	-12%	-11%

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Source: DSSAT

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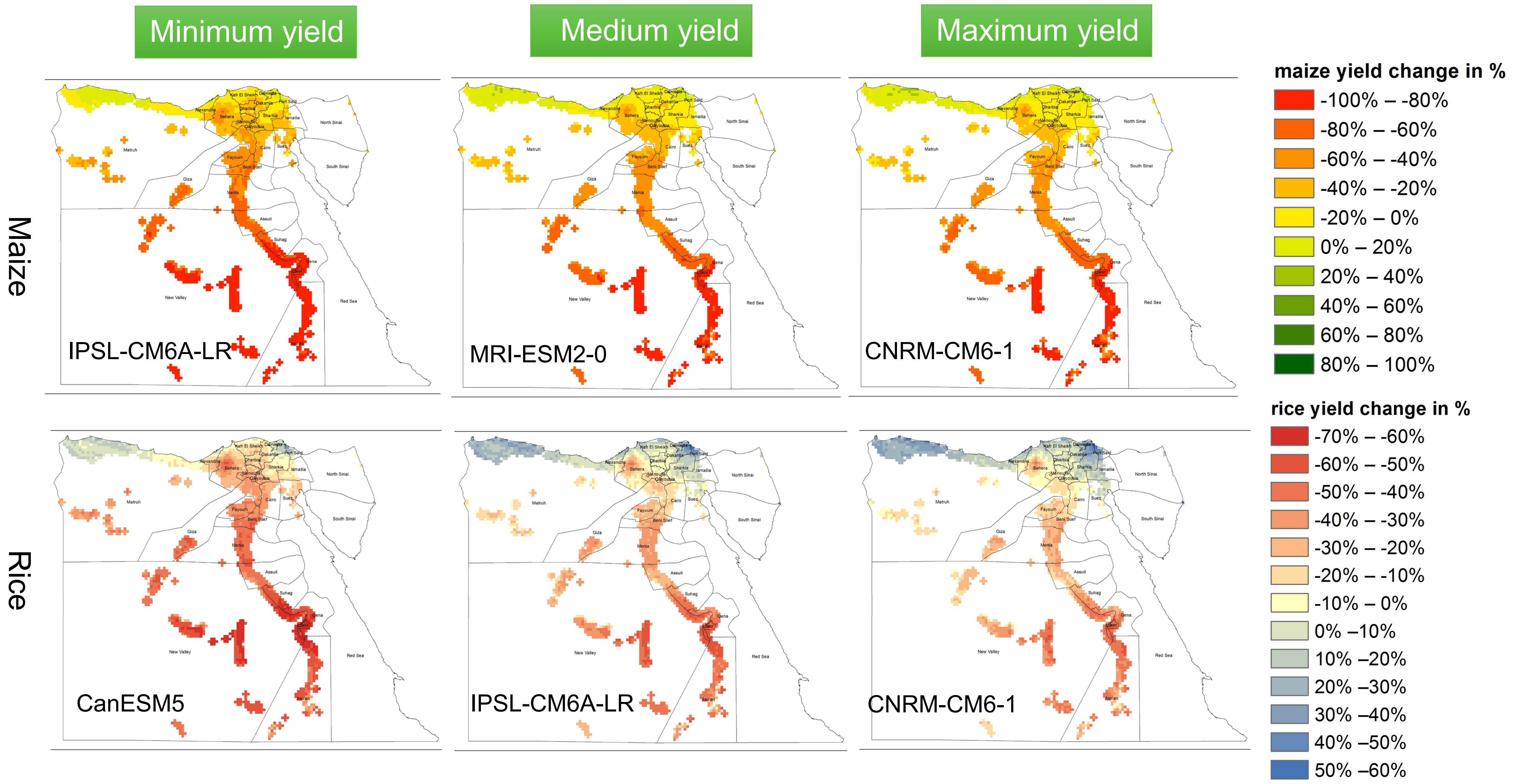
Climate Change Impact on Crop Yields, 2000 - 2050



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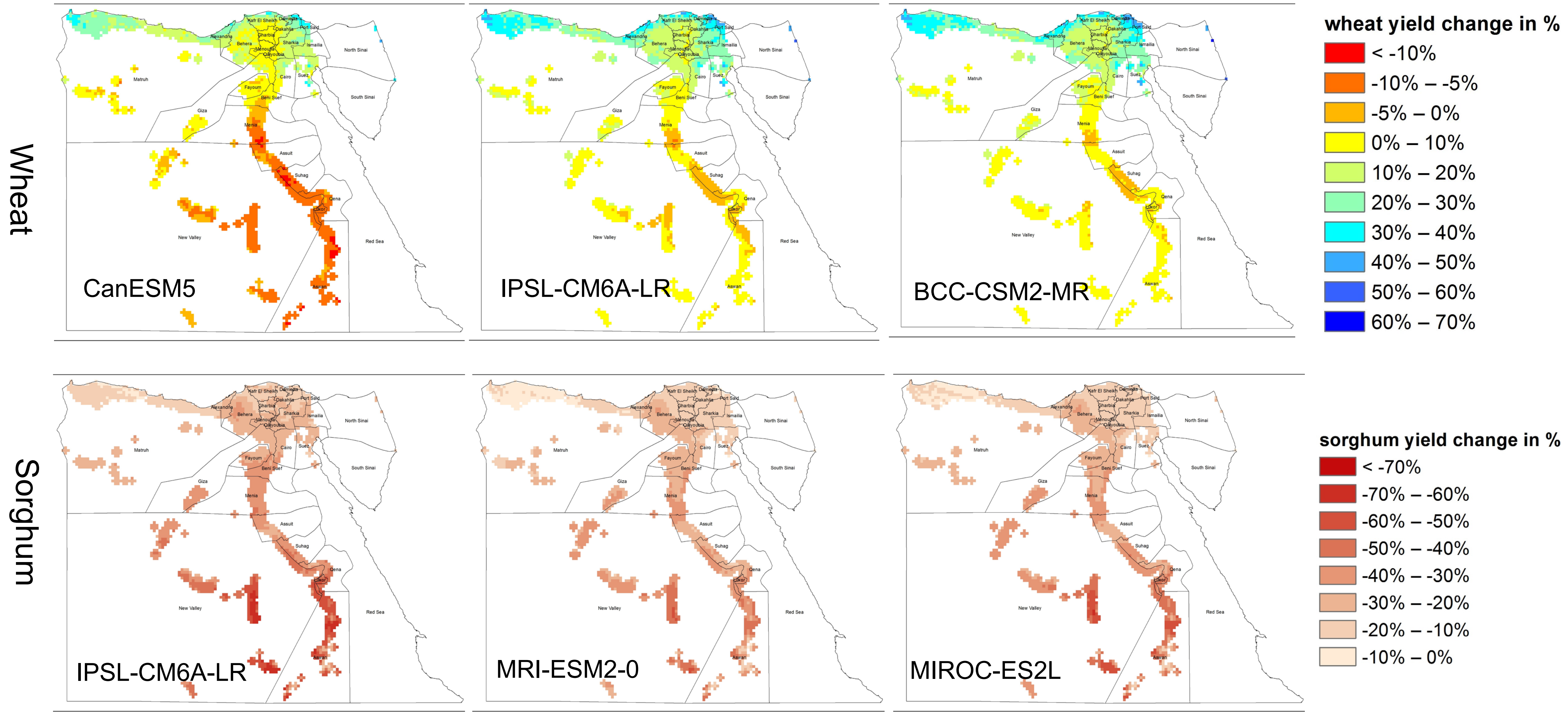
Climate Change Impact on Crop Yields, 2000 - 2050

Minimum yield | Medium yield | Maximum yield



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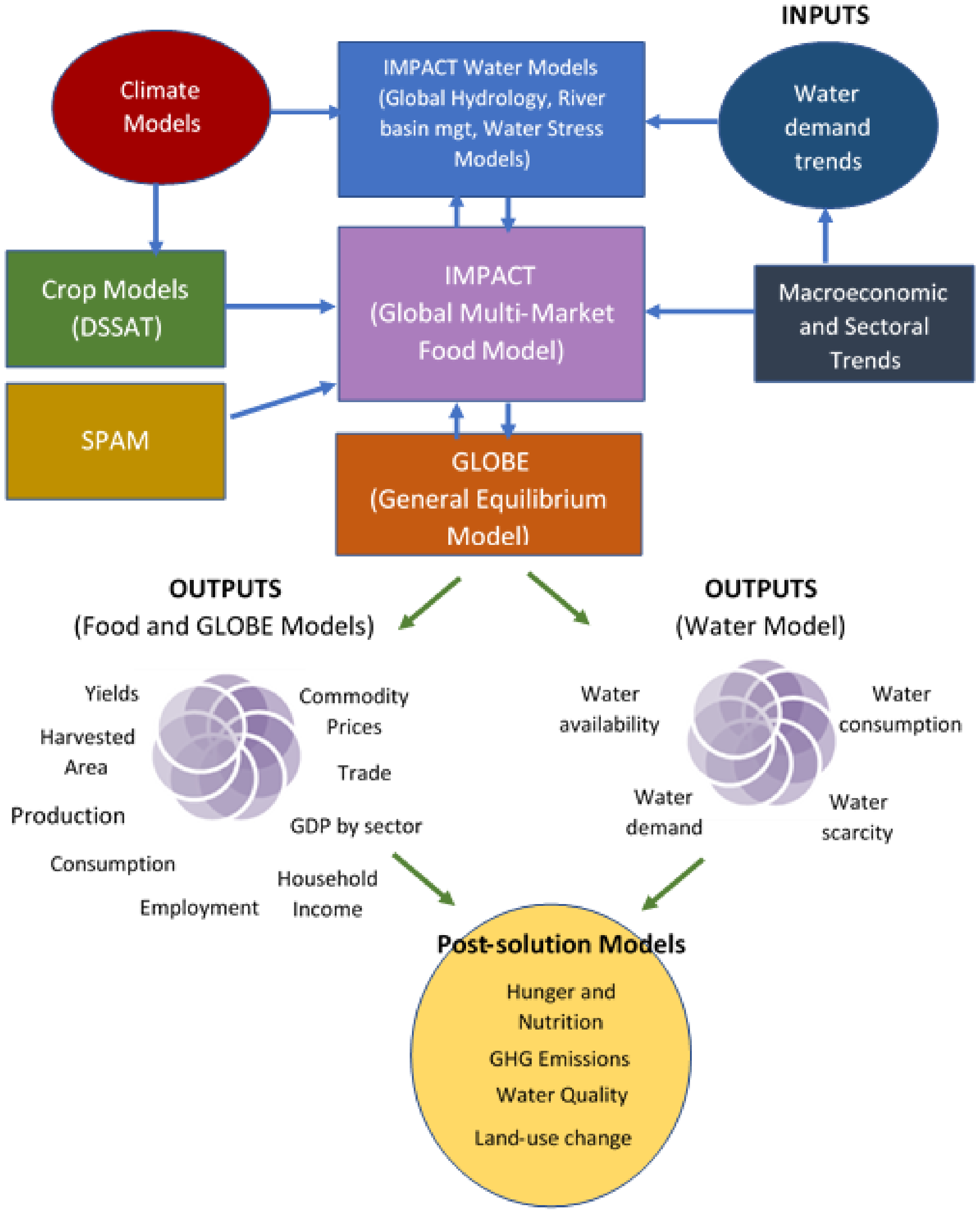
IMPACT model

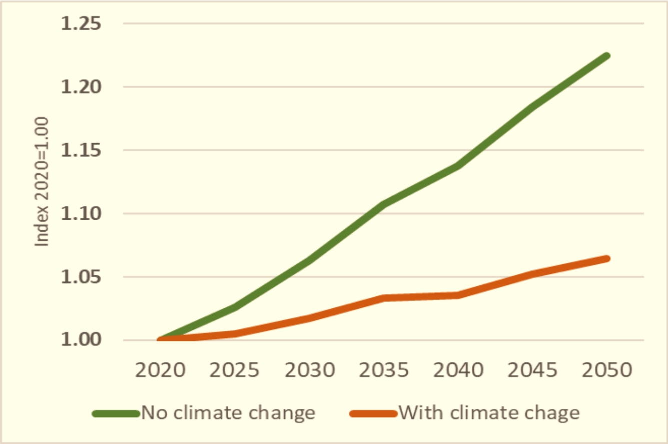
- Suite of biophysical and economic models including climate models, crop and water models, linked to CGE model
- Incorporates the effect of Climate Change
- Serves as investment assessment tool
- Global in scope – 159 countries and regions.
- Calibrated to Egypt

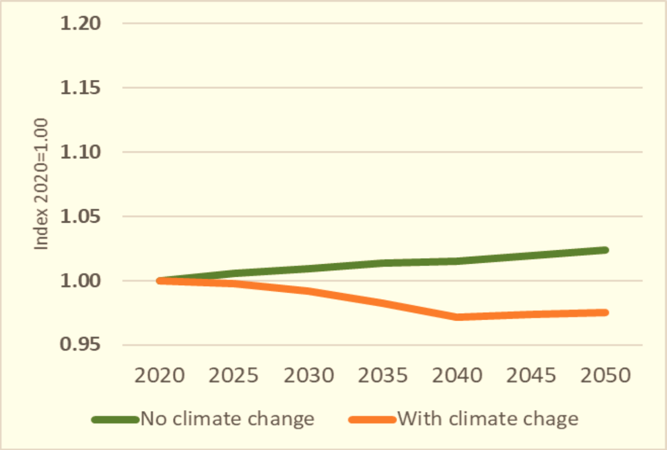


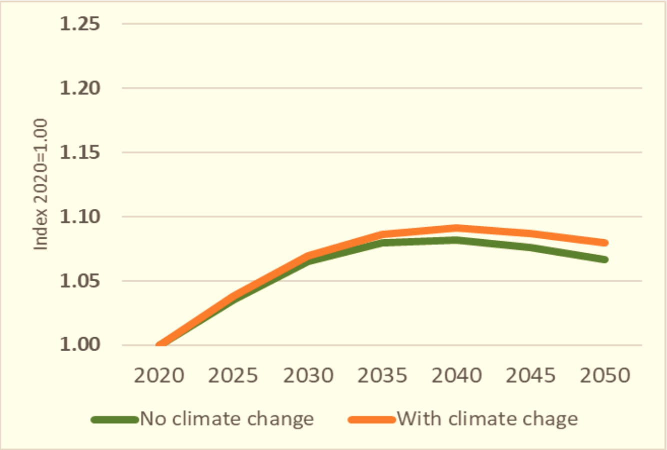
Direct impact of climate change – crop productivity

Maize | Rice | Wheat

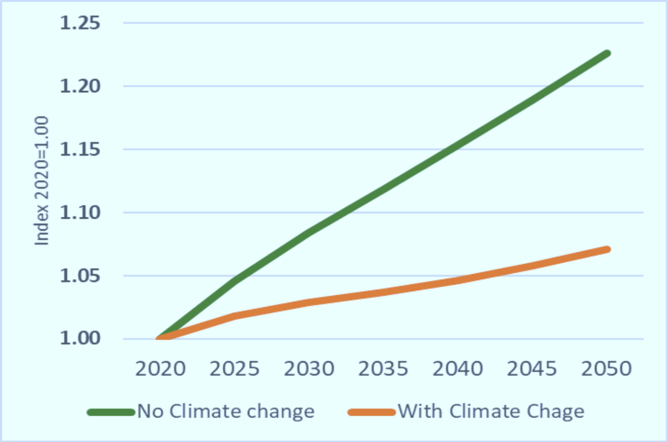
Egypt

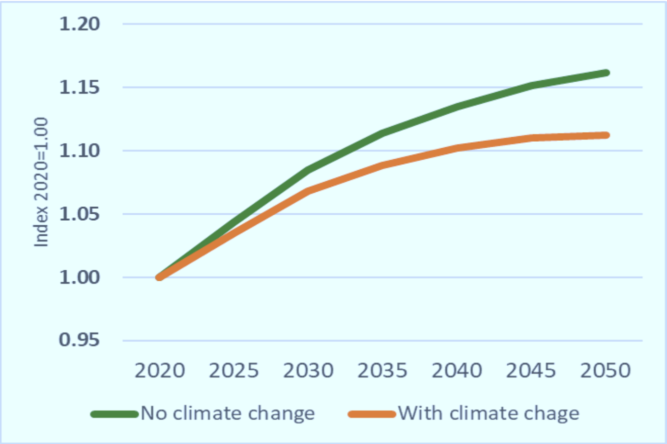


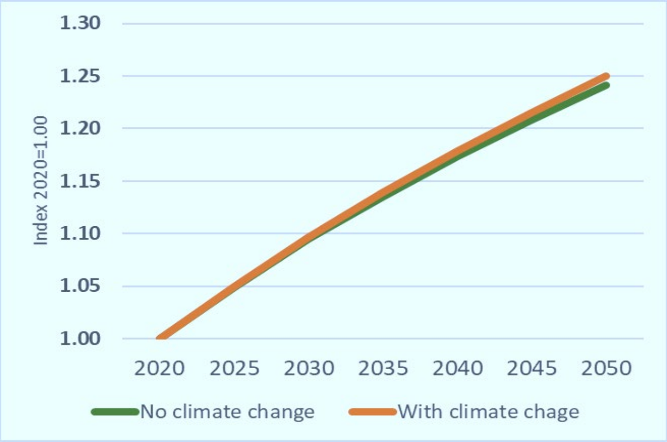




World







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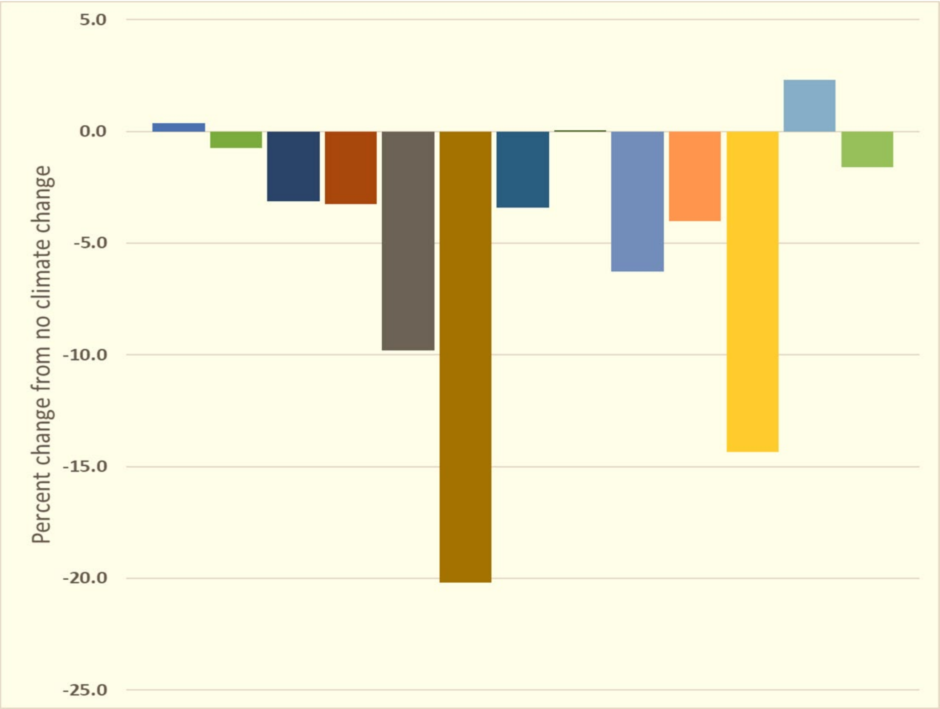
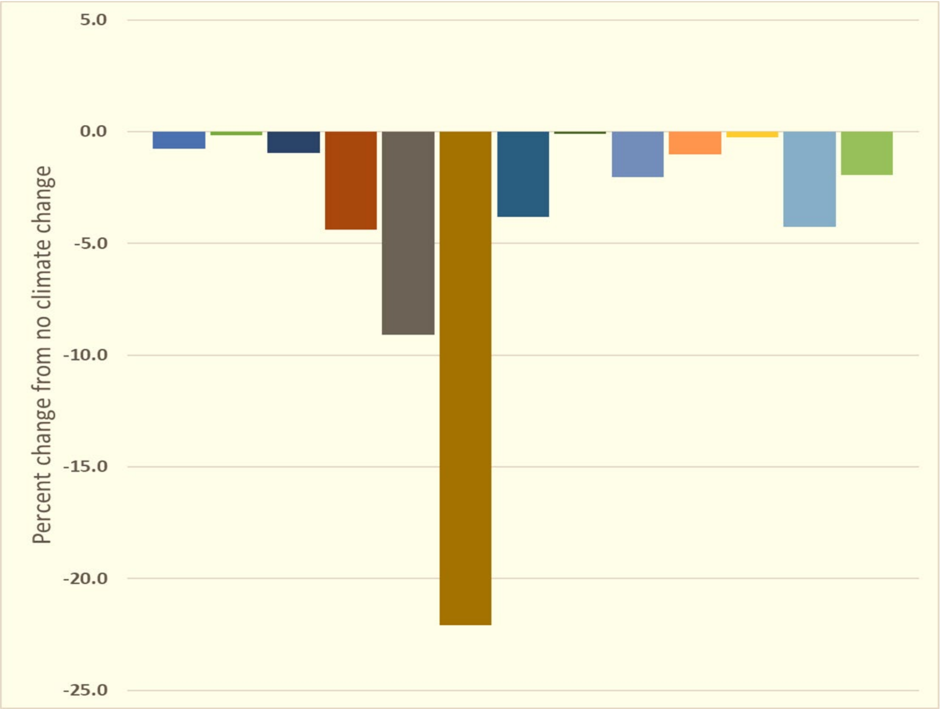
Source: IMPACT

Indirect Impact of Climate Change on Production, 2050

Egypt



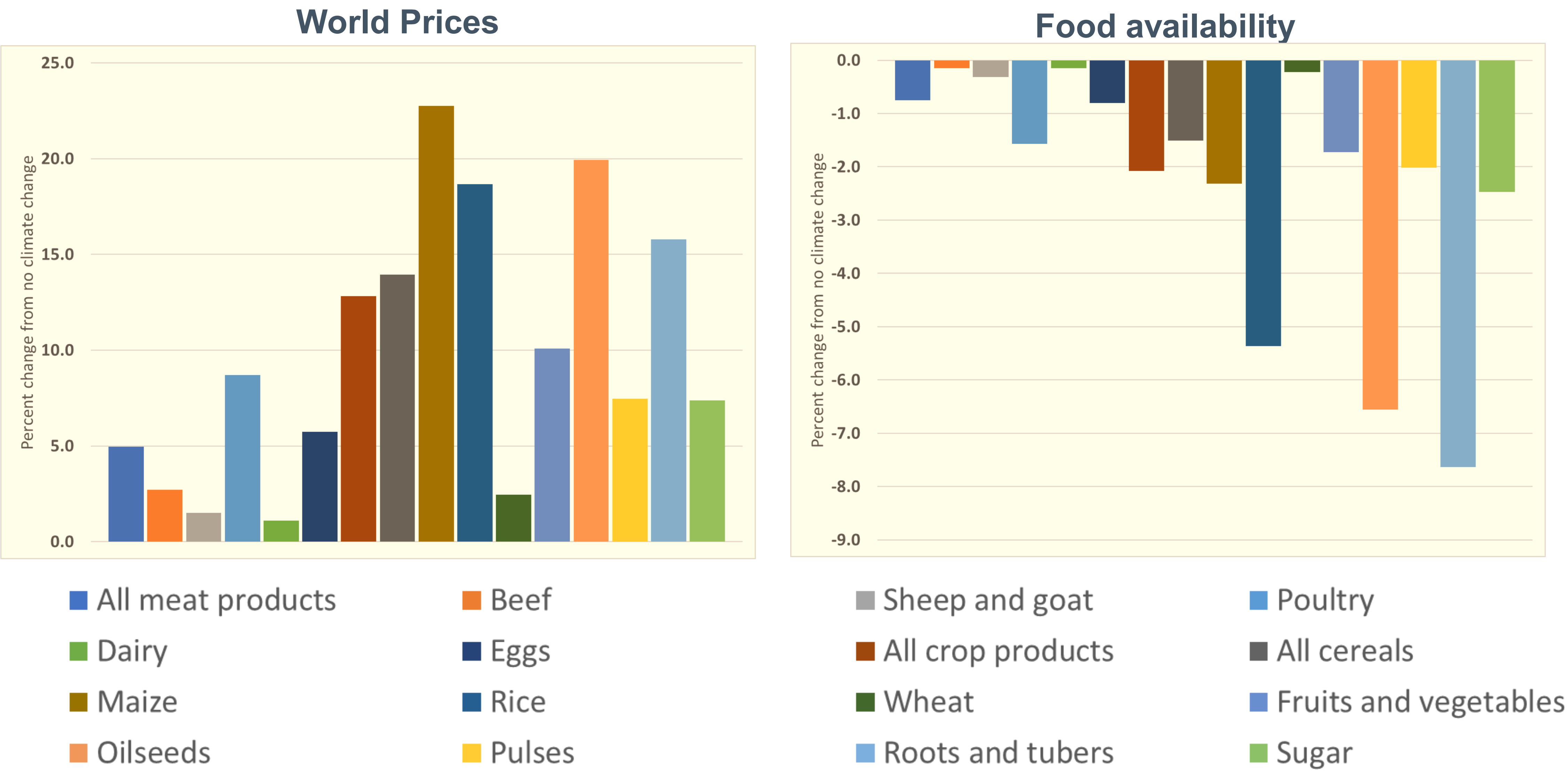
World



All meat products | Dairy | Eggs | All crop products | All cereals
Maize | Rice | Wheat | Fruits and vegetables | Oilseeds
Pulses | Roots and tubers | Sugar

Source: IMPACT

Impact of climate change on world prices and availability of food, 2050



Source: IMPACT

Welfare effect of climate change: 2010-2050

Climate models	Welfare Measure		
	Producer Surplus	Consumer Surplus	Economic Surplus
	net present value (billion US dollars)*		
World			
High	3,778	-7,227	-3,449
Median	2,138	-4,427	-2,288
Low	811	-1,733	-921
Egypt			
High	36	-98	-62
Median	10	-60	-49
Low	-7	-21	-28
Egypt			
Annual (median)	**0.25**	**-1.49**	**-1.23**

*Application of real discount rate equal to 3%

Source: IMPACT

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Adaptation to climate change – Through Promotion of Climate-Resilient Technologies

- Classify technologies according to farming activities
- Offer technology options within each category
- For early adaptors, possibility of technology-stacking – defined as adopting a mix of technology – taken from each technology group
- Uptake: 2020-2040, by which time adoption reaches 60-70% for wheat, maize and rice

Description of Selected CSA Technologies.

Technology Suite	Individual Technology
Seed Varietal Technologies	Heat tolerance
	Flood tolerance
	Drought tolerance
	Saline tolerance
	Enhanced nutrient -use efficiency
Soil Fertility Management Technologies	No-till and direct seeding
	Integrated soil fertility management
	Organic farming, brown and green manuring
	Full and partial intensification
	Precision agriculture
Irrigation Water Management Technologies	Water harvesting
	Laser land leveling
	Alternate wet and dry system
	Precision water application
Crop protection Technologies	Weeds protection
	Insects protection
	Diseases protection
Stacked Technologies	Mix of complementary technologies from seed variety, soil fertility, irrigation mgt and crop protection technology suite

Source: Constructed by authors and based on Rosegrant and others, 2014.

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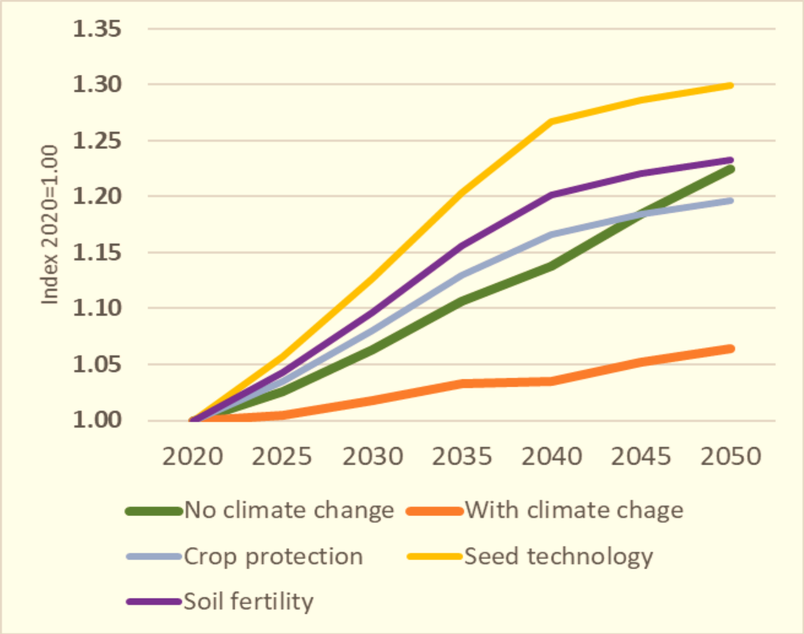
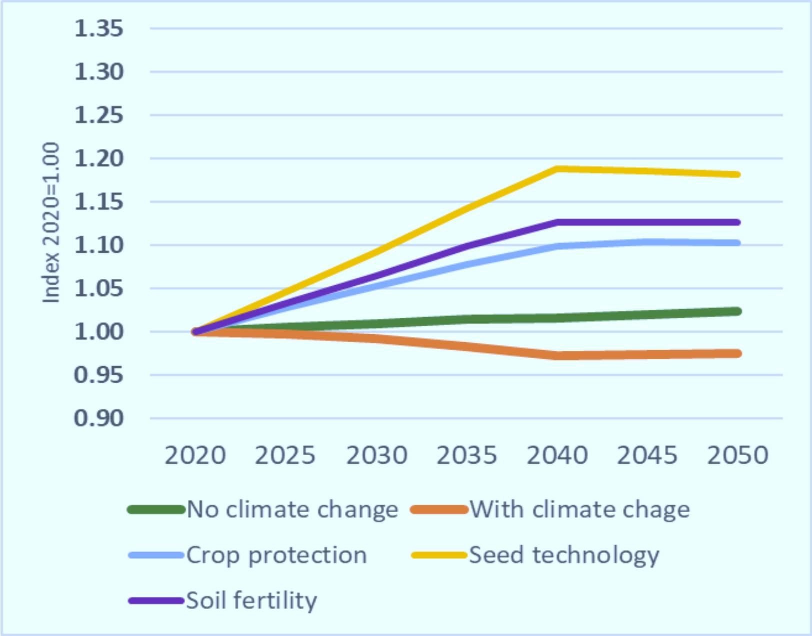
Technology simulations: Seed Technology, Soil Fertility Mgt and Crop Protection

Changes in yields

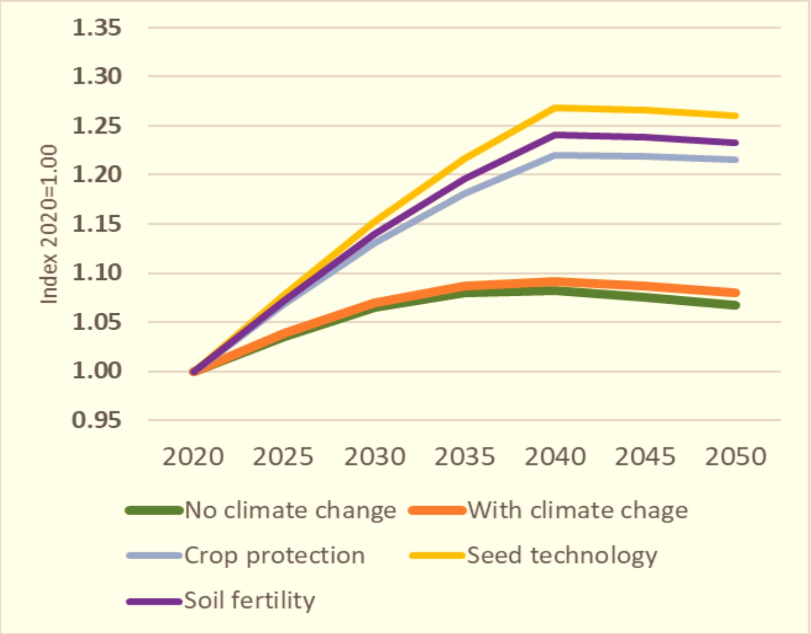
Maize



Rice



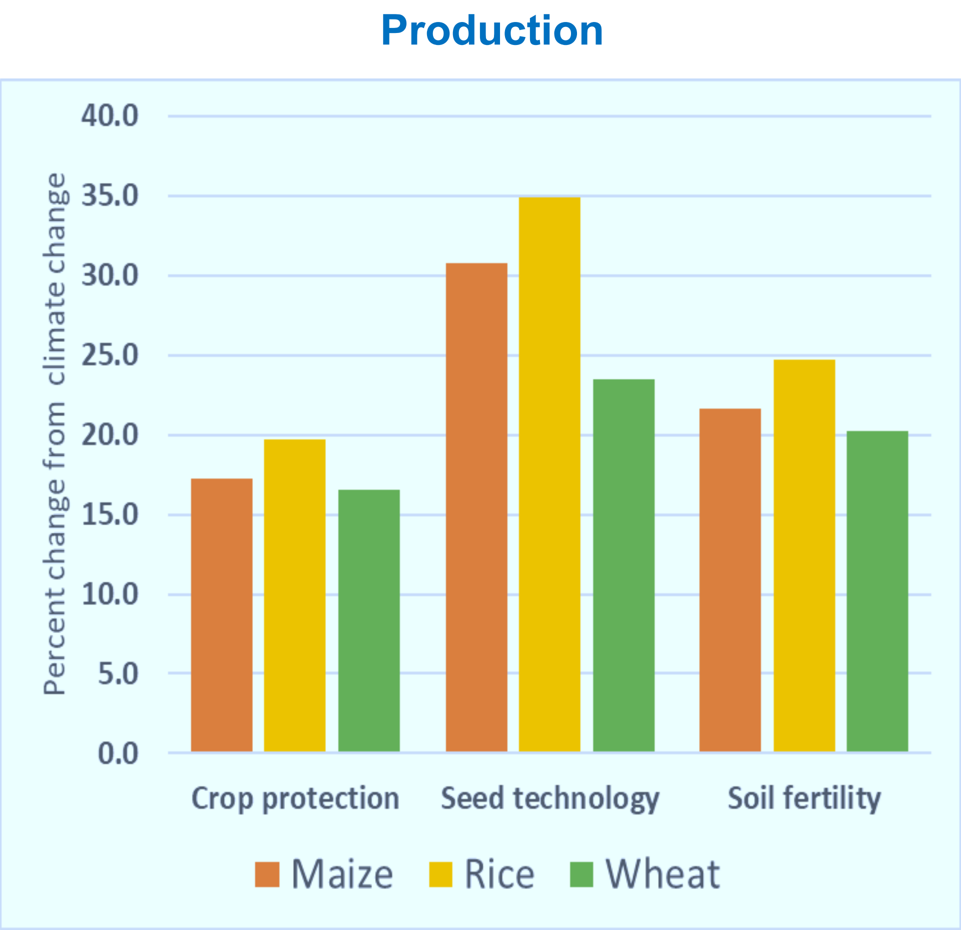
Wheat

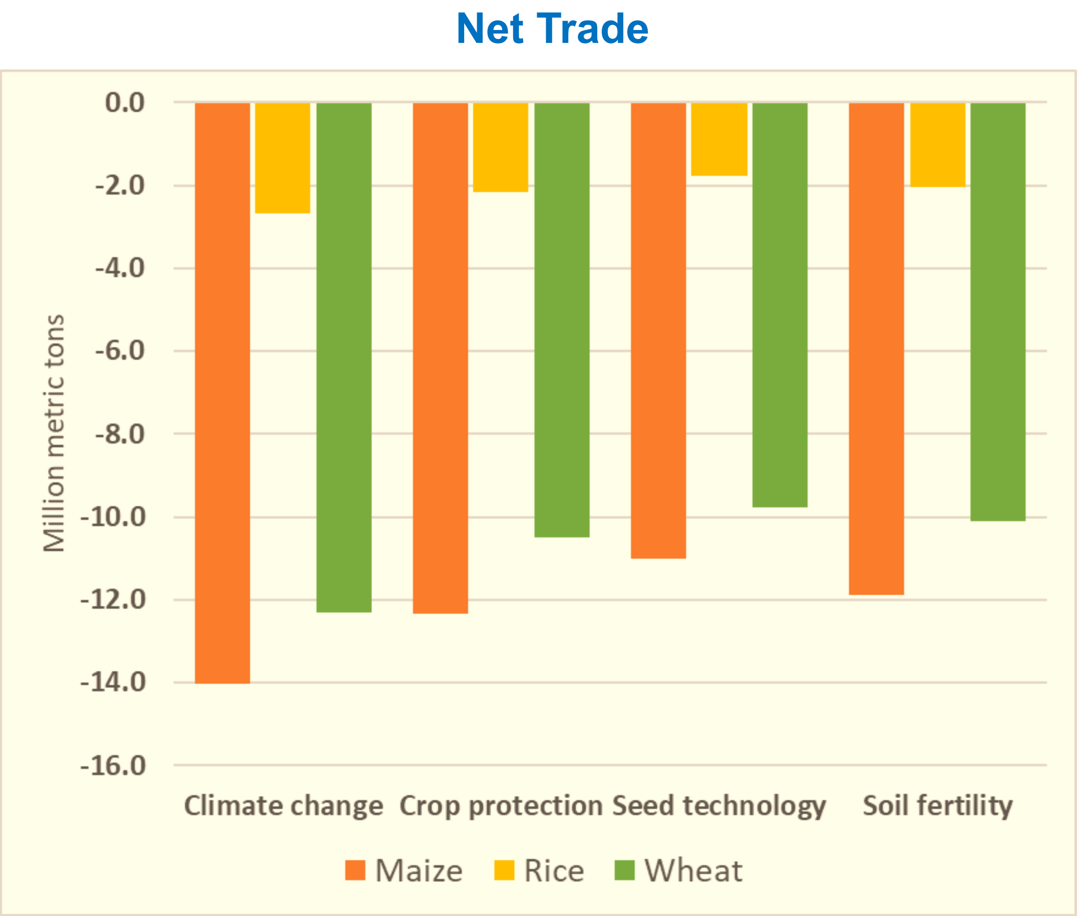


Source: IMPACT

Technology simulations: Seed Technology, Soil Fertility Mgt and Crop Protection

Changes in production and net trade, 2050





Source: IMPACT

Conclusions

- Climate change impacts for Egypt are very large: Medium temperature increases of 2-3.2 ºC; increased runoff--likely as flash floods, while dry season and hot days are growing in length and numbers
- Direct biophysical yield impact from +7 to -17% during 2020-2050; among cereals, only wheat yields expected to potentially benefit due to location closer to the Sea
- World prices expected to increase and food security to worsen and net cereal imports to increase

Conclusions

- Largest production declines in Egypt expected for maize, pulses, fruits and vegetables; some potential increase for meat production (f. ex. poultry)
- Welfare losses of 1.23 billion a year from consumer surplus declines→ warrant adaptation investment of the same level
- Direct water investment options are limited: Egypt's irrigation systems are relatively efficient: water is re-used many times before it reaches the Sea; increased WUE investment could increase salinity in the Delta

Recommendations

- Focus on additional investments in areas that directly fight climate change, such as seed technologies (highest impact across all technologies);
- those that enhance the productivity boost of irrigation (soil fertility improvement, precision agriculture); and
- those that protect against increased pests and diseases (growing with climate change) (somewhat less beneficial for maize)
- All three investments increase production and reduce net imports; need to take care that crop protection investment does not grow water pollution

Recommendations

- Soil fertility management can also help buffer increased climate shocks (heat days and flooding) and could be combined with additional water storage, such as managed groundwater recharge
- Investments in these technologies can generate yields that are higher than under a no-CC scenario but growth in non-irrigation water demands, particularly urban-industrial growth and salinity intrusion threats in the Delta suggest that crop areas cannot be profitably and sustainably further expanded—but additional potential to further shift to high-value (non-cereal) crops