

Climate change in agriculture: an analysis of the potential socioeconomic impacts in different Brazilian regions

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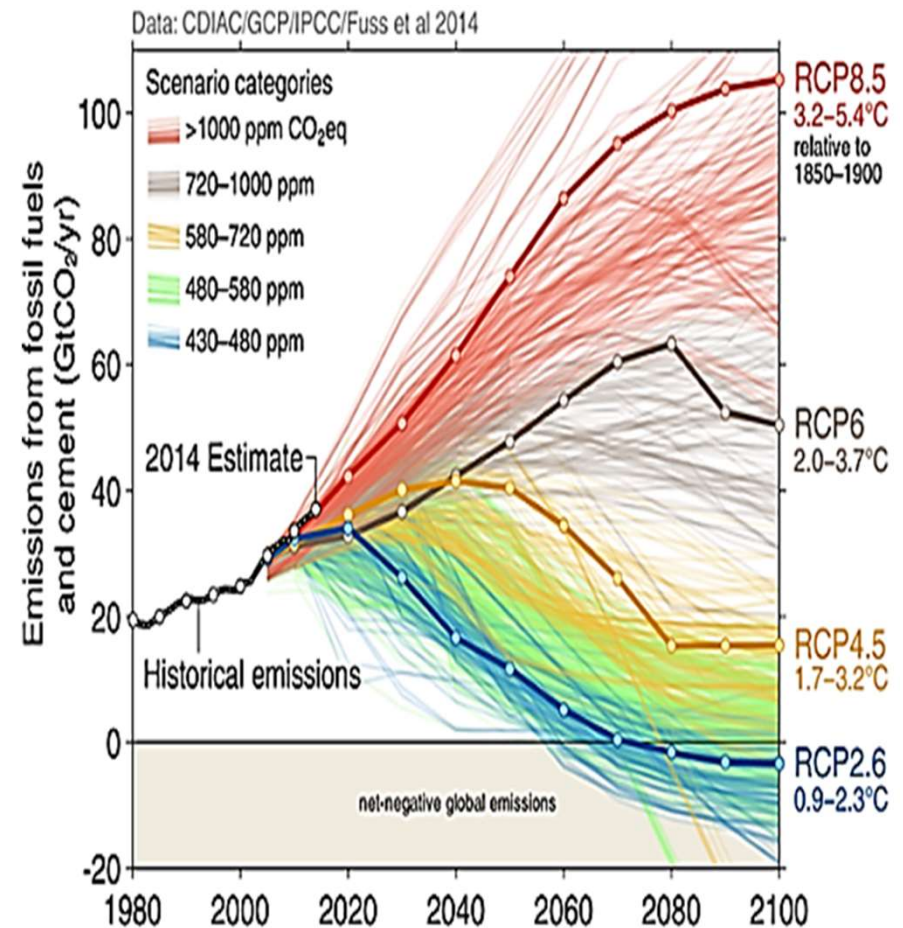
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EMBRAPA

Background

- The 4 most recent scenarios of the 5th Assessment Report - Representative Concentration Pathways (RCP) - RCP2.6, RCP4.5, RCP6.0 and RCP8.5 - reinforce projections of rising average temperatures on the planet by 2100.
- Probable increase between 2081-2100 compared to 1986-2005 is expected to be 0.3°. C to 1.7°. C in the milder scenario (RCP2.6), and 2.6°. C at 4.8°. C is not the most severe (RPC.8.5).



Climate change

- Agricultural sector: often identified as the most vulnerable.
- International literature on Climate Change and agriculture:
 - Differentiated impacts across the world.
 - Most affected regions: tropical and subtropical
 - Relatively few studies focusing on developing countries
 - Even fewer studies focus on inter-regional effects inside countries.

Objective

- Investigate the potential socioeconomic impacts of climate change on agriculture and the Brazilian economy as a whole:
 - Inter-regional approach.
 - Use results from the 5th IPCC report.
 - Compare results with previous (4th Report) studies.

Background

- In Brazil, previous evaluations used static bottom-up interregional CGE models and scenarios derived from the 4th. Assessment Report (AR) of the IPCC (2007).
- New results: scenarios for agriculture derived from the latest global climate projections – 5th. Assessment Report (AR5, 2014). They incorporate frequent advances and improvements added to these models.
- Inclusion of rainfall in the models used by Embrapa.

Methodology

- Use of a dynamic interregional EGC model for the Brazilian economy (TERM-BR model).
- Linearized, interregional, bottom-up, and dynamic (recursive dynamics).
- 27 regions of Brazil => later aggregated in 15 regions.
- 136 sectors => subsequently aggregated into 34 (11 from agriculture).
- 10 types of families.
- 10 types of workers.
- Base year: 2010. Solved using RunDynam / GEMPACK..

Simulation strategy and scenarios

- Policy shocks: based on the concept of loss of suitable (or low risk) area for agriculture due to climate change.
- 8 crops: cotton, rice, sugar, beans, corn, soybeans, sorghum and wheat: 83.41% of total area; 67.81% value of agricultural production (2012).
- All municipalities (5,568) in Brazil, generated by Embrapa Informática Agropecuária.
- Starting point: global climate scenarios. Two models:
- HadGEM-2 (United Kingdom): Hadley Center Global Environmental Model version 2 - Earth System
- MIROC5 (Japan): Model for Interdisciplinary Research on Climate version 5.

The loss of suitable (apt) area concept

- Adapted from the Agricultural Climate Risk Zoning (ZARC) methodology, developed by Embrapa and applied in Brazil since 1996.
- Low risk area combines minimal production conditions and chance of successful harvesting of the product under consideration: greater than or equal to 80%.
- If the opposite occurs, the area in question is considered to be of high risk, and not suitable for a particular crop. Not eligible for official rural credit or insurance programs.
- Future scenarios for each crop are constructed combining municipalities that have had low risk conditions for at least a decade and the soils that have a good capacity to support agricultural crops (clayey and medium textured) .

Loss of apt area estimates

- Embrapa: several methodological steps, starting from global climatic scenarios with global models :
- Hadley Center Global Environmental Model version 2, (HadGEM2-ES; and
- Model for Interdisciplinary Research on Climate version 5 (MIROC5).
- Results refined for the different regions of Brazil using a dynamic downscaling technique, through the regional climate model ETA, with a spatial resolution of 20 km x 20 km (Brazil, 2016).
- The regionalized climate model ETA: Center for Weather Forecast and Climate Studies of the National Institute for Space Research (CPTEC / INPE / MCTI).

Climate scenarios

- Two scenarios of AR5 (IPCC, 2014) were considered. Projections for all municipalities in Brazil:
 - RCP4.5: intermediate (less severe) - with some stabilization of GHG; and
 - RCP8.5: pessimistic (more severe) - very high GHG emissions and without mitigation.
 - HadGEM4.5
 - MIROC4.5
 - HadGEM8.5
 - MIROC8.5
- Average: Intermediate scenario (RCP4.5)
- Average: Pessimistic scenario (RCP8.5)

Table 1 - Shocks of variation (%) of suitable area by sector and region - Intermediate and Pessimistic Scenarios - (accumulated values for 2040)

Regions	Intermediate Scenario (RCP4.5)						Pessimistic Scenario (RCP8.5)					
	Sectors						Sectors					
	Rice and other cereals	Corn	Cotton	Sugar cane	Soybeans	Other annual corpos	Rice and other cereals	Corn	Cotton	Sugar cane	Soybeans	Other annual corpos
ParaRond	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RestN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MaraToc	0.00	0.00	0.00	0.00	-0.24	0.00	-0.06	0.00	0.00	0.00	-3.88	0.00
Piaui	-19.89	+1.21	-6.20	-3.36	-23.09	-2.45	-44.02	+20.46	-19.55	-19.72	+25.62	-10.30
RestNE	-10.91	-0.69	+1.04	-0.46	-24.97	+0.47	-16.97	+2.74	+0.51	-0.34	+8.99	+3.95
PernAlag	-11.56	-2.77	-1.92	-0.86	0.00	+0.88	-1.00	+16.84	-2.53	-1.99	0.00	+7.81
Bahia	-33.50	-28.56	-25.18	-24.72	-17.71	-14.01	-11.83	+22.85	-19.97	-22.65	+148.66	+5.16
MinasG	-12.02	-15.16	-11.49	1.94	-28.77	-10.83	-9.53	-0.45	-17.35	-4.04	-26.32	-15.61
RestSE	-59.26	-41.36	0.00	-19.38	0.00	-13.95	-66.73	-0.05	0.00	-24.75	0.00	-16.66
SaoPaulo	-31.86	-17.35	-0.99	+1.08	-49.54	-5.09	-29.96	0.00	-0.55	+1.08	-39.97	-3.25
Parana	-19.00	-12.82	0.00	+82.94	-90.50	-6.28	-28.48	0.00	0.00	+82.94	-48.85	-6.97
RestS	0.00	0.00	0.00	+82.94	-64.59	0.00	0.00	0.01	0.00	+82.94	+232.52	0.00
MtGrSul	-26.71	-19.92	-0.01	0.00	-68.97	-5.92	-25.15	-0.01	0.00	0.00	-41.43	-2.83
MtGrosso	0.00	0.00	0.00	0.00	-1.45	0.00	0.00	0.00	0.00	0.00	-1.19	0.00
RestCO	0.00	0.00	0.00	0.00	-0.13	0.00	-0.05	0.00	0.00	0.00	-2.53	0.00

Main results: macroeconomic variables

	AR5	AR5	AR4*	AR4*
	Intermediate (RCP4.5) 2040	Pessimistic (RCP8.5) 2040	A2/20 (no adaptation)	B2/70 (with adaptation)
Households	-0,12	-0,07	-0,70	-2,09
Real investment	-0,18	-0,10		
Exports (volume)	-0,42	+0,15		
Imports (volume)	-0,30	+0,10		
GDP (real)	-0,15	-0,04	-0,28	-1,12
Real wages	-0,05	-0,09	-0,53	-1,81
Capital stock	-0,08	-0,03		

Diferential effects of
including rainfall in the
crops models

(*) Ferreira Filho and Moraes (2014)

Production (% change accumulated in 2040)

Agricultural Activity		Intermediate Scenario (RCP4.5)	Pessimistic Scenario (RCP8.5)
		Production	Production
Rice and other cereals		6.77	-10.48
Corn		2.28	-0.45
Cotton		-1.47	-3.05
Sugar cane		3.89	2.01
Soybeans		-30.26	0.24
Other annual crops		2.29	-1.54
Coffee		2.42	0.83
Other permanent crops		1.02	-1.02
Livestock		2.14	-0.92
Milk production		1.95	-0.92
Hogs and poultry		0.71	-0.33
Forestry		3.02	-0.93

Results (AR5)

Table 1. Percentage change in employment, by agricultural activities - Brazil - (accumulated for 2040)

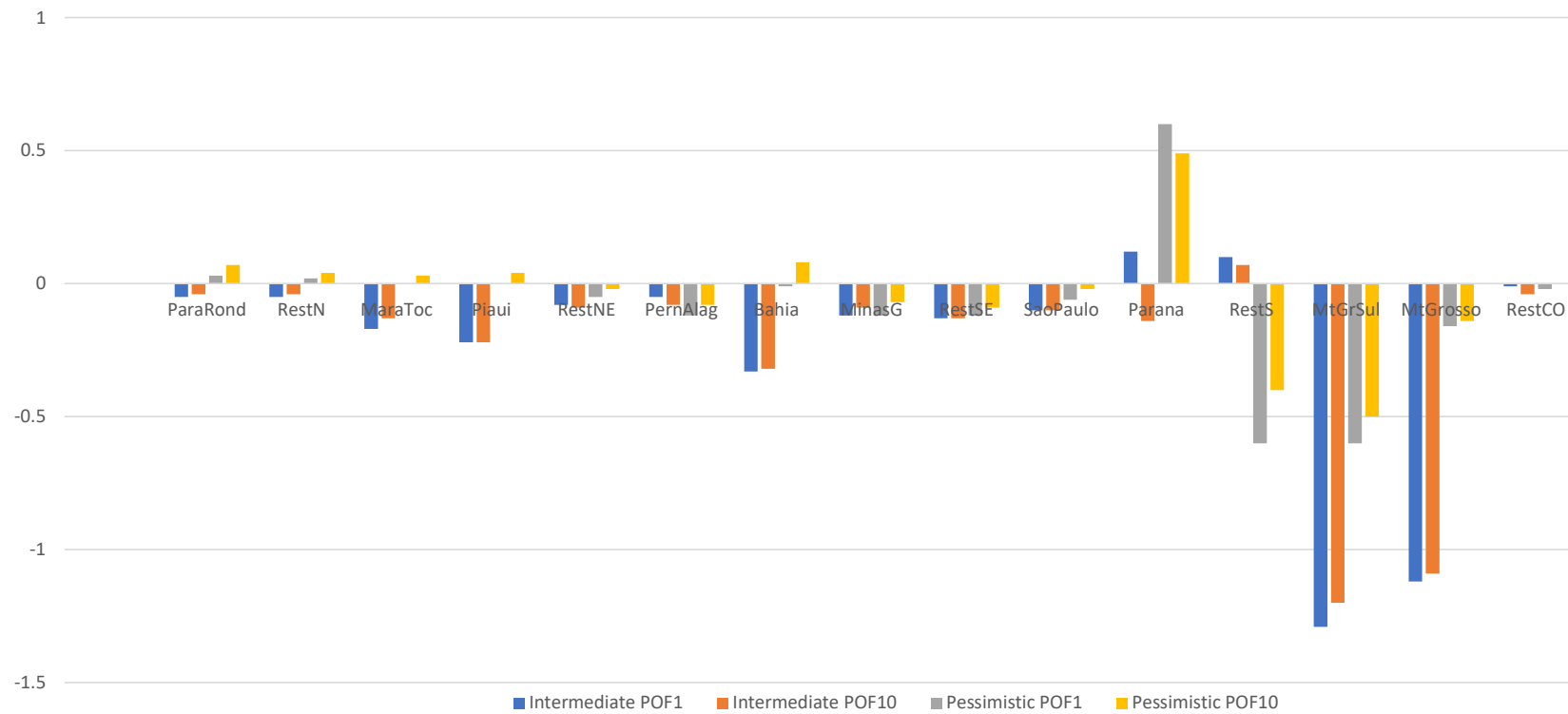
Agricultural Activity	Employ	
	Intermediate Scenario (RCP4.5)	Pessimistic Scenario (RCI)
Rice and other cereals	5.41	-8.65
Corn	1.83	-0.37
Cotton	-0.60	-1.98
Sugar cane	3.58	1.97
Soybeans	-22.32	1.79
Other annual crops	0.68	-0.60
Coffee	2.05	0.73
Other permanent crops	0.19	-0.48
Livestock	1.26	-0.60
Milk production	0.50	-0.29
Hogs and poultry	0.60	-0.33
Forestry	1.46	-0.47

Regional real GDP variation

	AR5	AR5	AR4	AR4
Região	Intermediate (RCP4.5) 2040	Pessimistic (RCP8.5) 2040	A2/20 (No adaptation)	B2/70 (with adaptation)
ParaRond	-0,01	+0,02		
RestN	0,00	+0,01		
MaraToc	-0,03	-0,02		
Piaui	-0,11	+0,02	-12,06	-16,39
RestNE	-0,04	-0,01		
PernAlag	-0,02	-0,07		
Bahia	-0,20	+0,03	-1,57	-2,34
MinasG	-0,03	-0,04	+0,19	-0,88
RestSE	-0,09	-0,06		
SaoPaulo	-0,04	-0,01	+1,05	+0,50
Parana	1,24	+0,07	-0,73	-3,88
RestS	-0,09	-0,23		
MtGrSul	1,98	-0,83	-7,19	-9,11
MtGrosso	-0,37	-0,09	-8,48	-11,20
RestCO	0,00	-0,01	+0,12	-1,46*

Real household consumption

POF1: poorest household
POF10: richest



Final remarks

- The estimated GDP loss for Brazil is small, and smaller than observed in previous similar study.
- The pessimistic scenario is less harmful for Brazil than the intermediate one.
- Soybeans supply would be severely affected in the intermediate scenario.
- Regions will be affected differently, depending on their exposure to soybeans as a source of income.
- The Center-West and RestS (Rest of South) regions of Brazil shows the worse impacts, especially in the Intermediate scenario.
- Welfare effects (consumption) heterogeneous across households. In “loosing” regions the poorest are more negatively affected.
- High level of uncertainty in the analysis: significant changes comparing AR4 x AR5.