A new empirical evidence on the impact of global warming on rice market equilibrium in West Africa: Dealing with future uncertainties through Monte Carlo simulations

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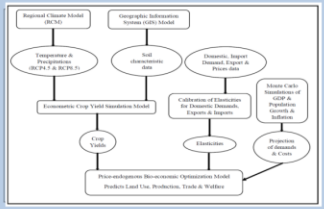
RESEARCH OBJECTIVE

Bring new empirical evidence on the effects of climate change on rice market equilibrium in 13 West African countries while dealing with uncertainties of predictions of future socio-economic scenarios using Monte Carlo simulations.

RESEARCH QUESTIONS

- Is there a better way to develop a regional agricultural optimization model and deal with future socio-economic scenarios in an environment with scarce dataset availability?
- How rice production, price and trade would behave under RCP 4.5 and RCP 8.5 relatively to a BAU scenario without climate change in West Africa?
- What are the welfare implications in the domestic as well as in the international markets of rice trade in a context of global climatic change in West Africa?

MODEL STRUCTURE



METHODS

The bioeconomic model uses mathematical programming to maximize the net present value of the consumers' and producers' surpluses to find optimal land allocation among a set of crops. The parameters of the model are :

- Average 2010 crop yields from the 39 agro-climatic zones with three soil types
- Yields depend on rainfall with very low irrigation capabilities and are projected up to 2100 with 10 years steps.
- Elasticities of demand are computed using a revealed preference approach drawn from a practice in the calibration of CGE models.
- The model is calibrated to replicate 2010 observed land use. Monte Carlo simulations: parametric distributions using 1980-2010 population growth, economic growth and inflation data.
- These parametric distributions are simulated 300 times.
- Demand grows with population and economic growth. Production costs grow at the inflation rate.

BASELINE (BAU) SIMULATION RESULTS

Share of domestic rice in total consumption in the BAU scenario

	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100
Benin	0.17	0.07	0.05	0.05	0.08	0.03	0.03	0.08	0.02	0.02
Burkina Faso	0.53	0.21	0.22	0.29	0.08	0.15	0.17	0.19	0.51	0.54
Cote d'Ivoire	0.58	0.61	0.49	0.57	0.56	0.31	0.61	0.30	0.81	0.86
The Gambia	0.12	0.11	0.12	0.10	0.12	0.20	0.23	0.30	0.38	0.31
Ghana	0.60	0.30	0.23	0.11	0.19	0.26	0.11	0.18	0.21	0.52
Guinea	0.87	0.09	0.15	0.29	0.57	0.16	0.56	0.67	0.15	0.17
Guinea Bissau	0.78	0.30	0.36	0.39	0.60	0.30	0.31	0.31	0.33	0.60
Mali	0.98	0.30	0.98	0.80	0.98	0.86	0.90	0.29	0.29	0.35
Niger	0.17	0.07	0.04	0.16	0.08	0.01	0.13	0.72	0.03	0.04
Nigeria	0.70	0.35	0.26	0.36	0.36	0.28	0.31	0.32	0.26	0.24
Senegal	0.16	0.27	0.31	0.31	0.10	0.22	0.11	0.12	0.25	0.16
Sierra Leone	0.91	0.28	0.19	0.21	0.11	0.07	0.29	0.98	0.16	0.98
Togo	0.61	0.31	0.23	0.26	0.35	0.32	0.28	0.24	0.90	0.91

- The share of domestic rice were already less than 50% in the base year (2010) for 4 countries
- Under the BAU, 1% yearly increase in average rice yields is assumed.
- In the BAU results, the shares of domestic rice have decreased in several countries
- Some countries have returned to their 2010 level by the end of the century (Burkina Faso, Cote d'Ivoire, Senegal, Sierra Leone and Togo)

RESULTS UNDER RCPs RELATIVE TO THE BAU

Share of domestic rice in total consumption under RCP 4.5 and RCP 8.5 relative to the BAU scenario

	2020		2050		2100	
	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
Benin	-0.018	-0.02	-0.028	-0.03	0.024	0.01
Burkina Faso	0,039	0.06	0,171	0.15	-0.249	-0.33
Cote d'Ivoire	-0.399	-0.41	-0.146	-0.33	-0.161	-0.70
The Gambia	0.175	0.12	0.026	0.21	0.066	-0.14
Ghana	-0.160	-0.10	-0.167	-0.16	-0.237	-0.29
Guinea	0.633	0.69	0.417	0.34	0.518	0.49
Guinea Bissau	0.080	0.02	-0.044	-0.06	-0.143	-0.18
Mali	-0.093	-0.07	-0.724	-0.64	-0.268	-0.32
Niger	-0,005	-0.02	-0.066	-0.05	0.006	-0.02
Nigeria	0.157	0.00	0.252	0.07	0.195	-0.07
Senegal	-0.177	-0.17	-0.247	-0.26	-0.345	-0.41
Sierra Leone	0.090	-0.09	-0.038	-0.05	-0.097	-0.62
Togo	-0.014	-0.03	-0.025	-0.03	-0.726	-0.77

PRICE EQUILIBRIUM RESULTS UNDER RCPs

- Under the RCP 4.5, the results on the relative international to domestic prices are mixed
- Negative impacts in some countries, and alternate positive and negative effects in others.
- Domestic prices have grown more under the RCP 8.5 scenario relative to the BAU scenario for countries such as Cote d'Ivoire, Ghana, Senegal and Togo.

Welfare change from baseline in rice market (in USD)

	Welfare from Domestic		Welfare from Imports	
	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
Benin	-7.6E+16	-7.10E+11	3.16E+11	3.15E+11
Burkina Faso	-1.7E+14	-9.16E+13	-8.44E+09	-1.55E+10
Cote d'Ivoire	-3.6E+15	-9.63E+11	1.46E+15	-8.17E+10
The Gambia	-3.5E+20	-4.94E+14	7.35E+09	7.20E+08
Ghana	-1.9E+36	1.96E+19	1.52E+10	1.81E+10
Guinea	-1.6E+27	-2.22E+23	6.23E+11	6.25E+11
Guinea Bissau	-1.4E+13	-8.70E+11	6.71E+09	5.06E+09
Mali	-7.3E+16	-6.02E+11	-1.41E+13	-6.09E+12
Niger	-3.4E+16	2.73E+12	6.49E+15	1.05E+10
Nigeria	-2.9E+30	-1.46E+18	2.93E+11	-1.02E+11
Senegal	-6.3E+15	-4.17E+11	-2.10E+10	-2.41E+10
Sierra Leone	-3.5E+20	1.40E+14	6.31E+11	3.86E+11
Togo	-6.0E+17	1.25E+13	-1.71E+16	-1.35E+10

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