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Trade Policy Implications of climate change impacts on current and future agricultural systems in the semi-arid regions of West Africa

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AgMIP The Agricultural Model Intercomparison and Improvement Project

Background

- Agriculture in semi-arid regions of West Africa: mainly rainfed with a large number of smallholder farmers dependent on it for their livelihoods;
- Smallholder farmers in crop-livestock systems coping with low productivity and structural constraints (unfavorable climatic conditions, poor soil quality, limited resource endowment and adverse policies);
- Peanut based farming systems are important but exposure to international trade/prices can heighten vulnerability to shocks
- Climate change with higher temperatures, changing patterns of precipitation and increased frequency of extreme weather, superimposed on systemic and structural constraints
- Consequences: Lower yields, heightened food insecurity and vulnerabilities, negative impacts on well-being

Objectives:

- Explore the impacts of climate change on the economic vulnerability of farm households in Nioro, Senegal (under both current and future agricultural systems).
- Interrogate policy implications of the climate impact on peanut export

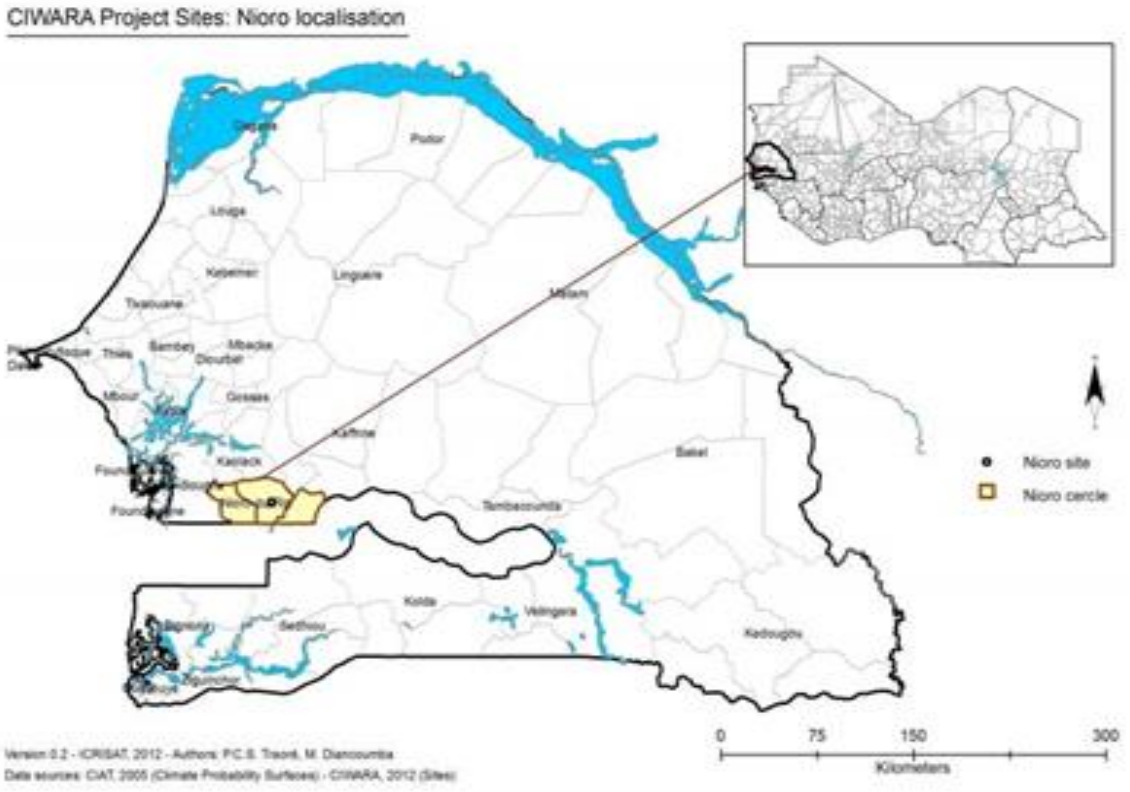
Background - Nioro

- Crops simulated and models used: Millet, Maize, Peanut (DSSAT and APSIM)

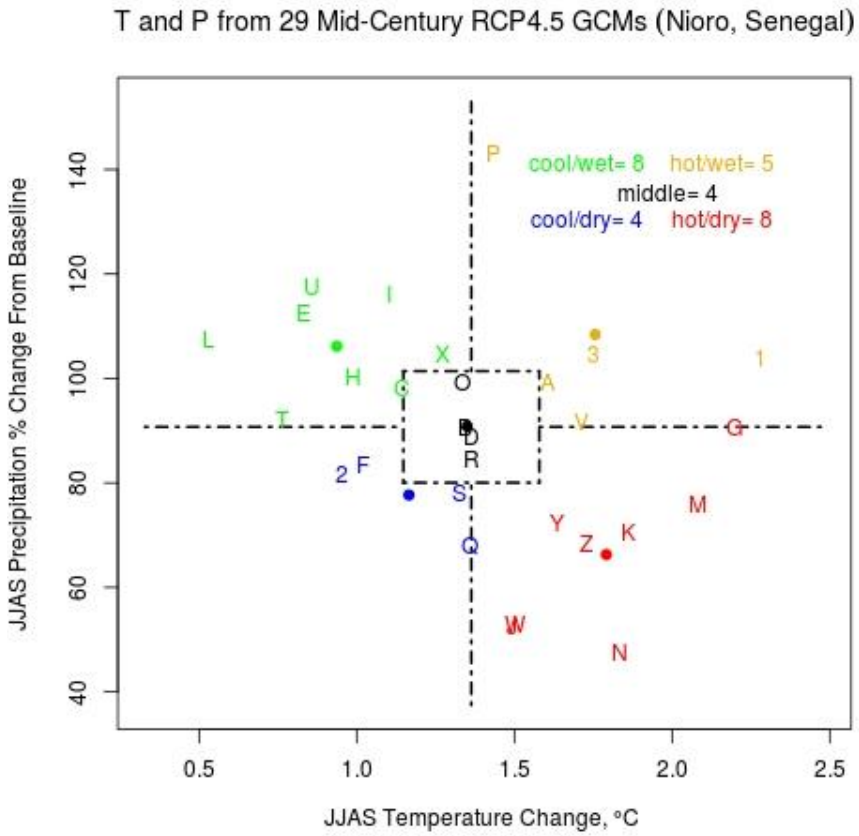
- Farm Systems Analyzed: Cereal-legumes-Livestock

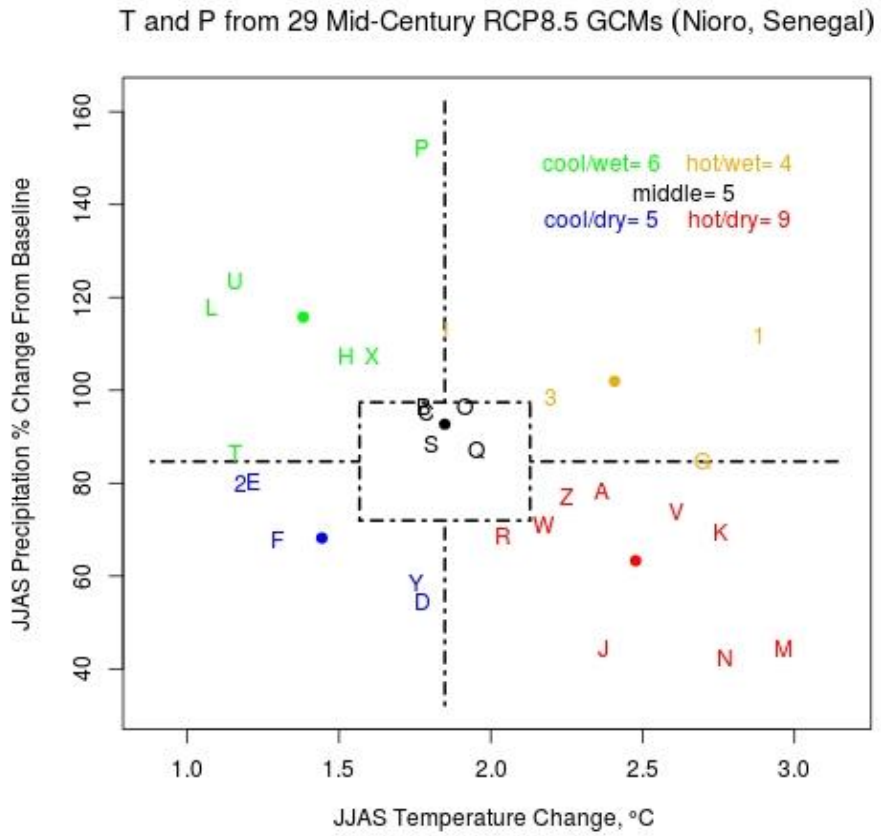
- Economic strata examined:
- No maize with livestock
- No maize without livestock
- maize with livestock
- maize without livestock

- Economic survey data utilized and number of farms:
- 2007 World Bank RuralStruc, 226 households



Choice of climate models



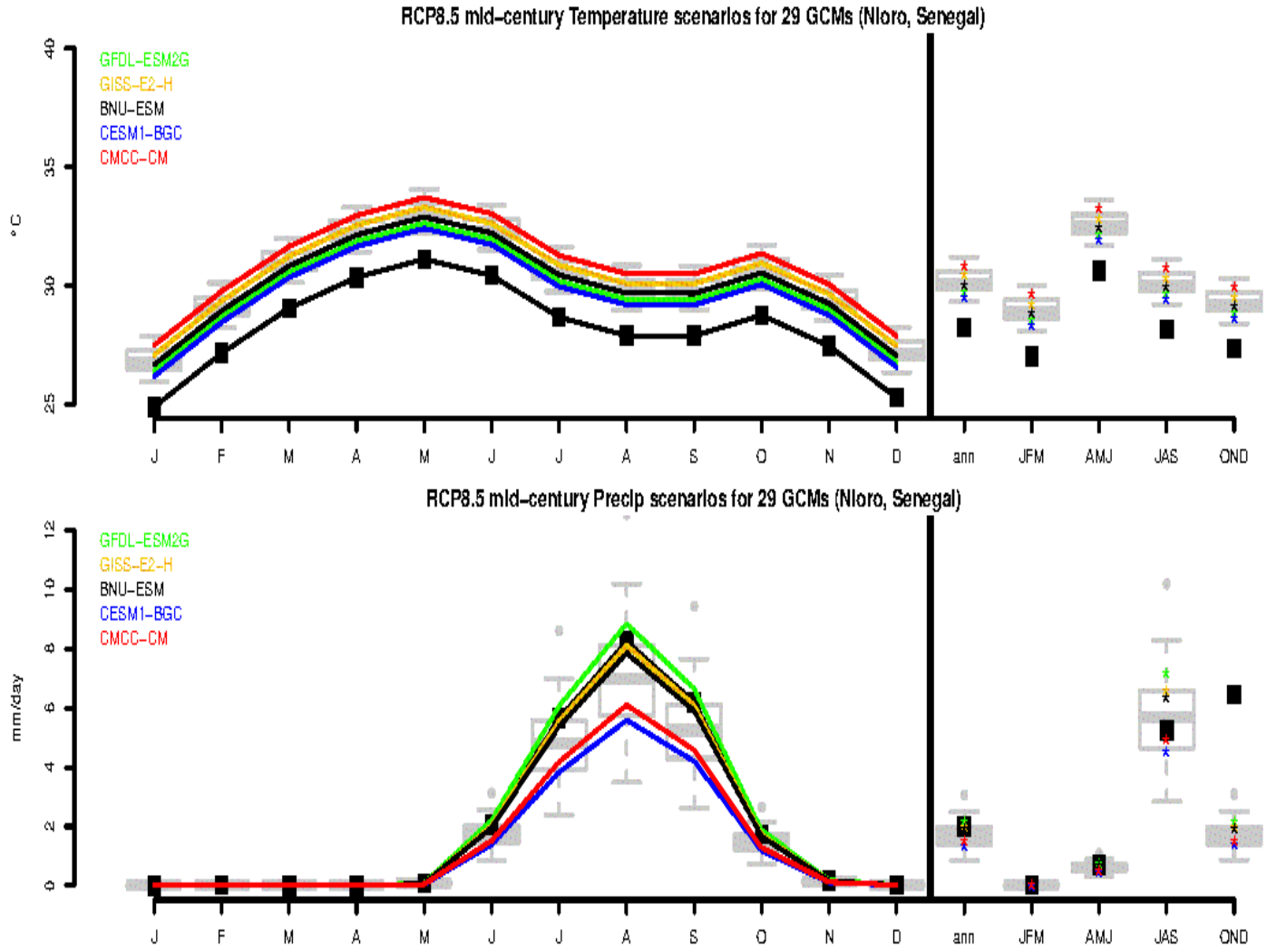


	Cool/Wet	Hot/Wet	Middle	Cool/Dry	Hot/Dry
RCP85	GFDL-ESM2 (H)	GISS-E2-H (3)	BNU-ESM ©	CESM1-BGC (F)	CMCC-CM (V)
RCP45	GFDL-ESM2 (H)	GISS-E2-H (3)	Bcc-csm1-1 (B)	MRI-CGCM3 (S)	IPSL-CM5B-LR (Z)

Average Temperature and rainfall change w/r baseline

Climate Scenario	Temp Δ°C		Rainfall Δ %		Rainfall Events %	
	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
Baseline	28.24 °C		741mm		46 days	
Cool/Wet	0.99	1.52	0	7	1	2
Hot/Wet	1.75	2.20	5	-2	5	0
Middle	1.34	1.79	-9	-5	-6	-6
Cool/dry	1.33	1.30	-22	-32	-14	-37
Hot/dry	1.73	2.61	-32	-26	-29	-40

Nioro climate projections



Projected average monthly rainfall at Nioro, Senegal, for 29 GCMs.

The black line with squares represents average values for the 30-year reference period (1981-2010);

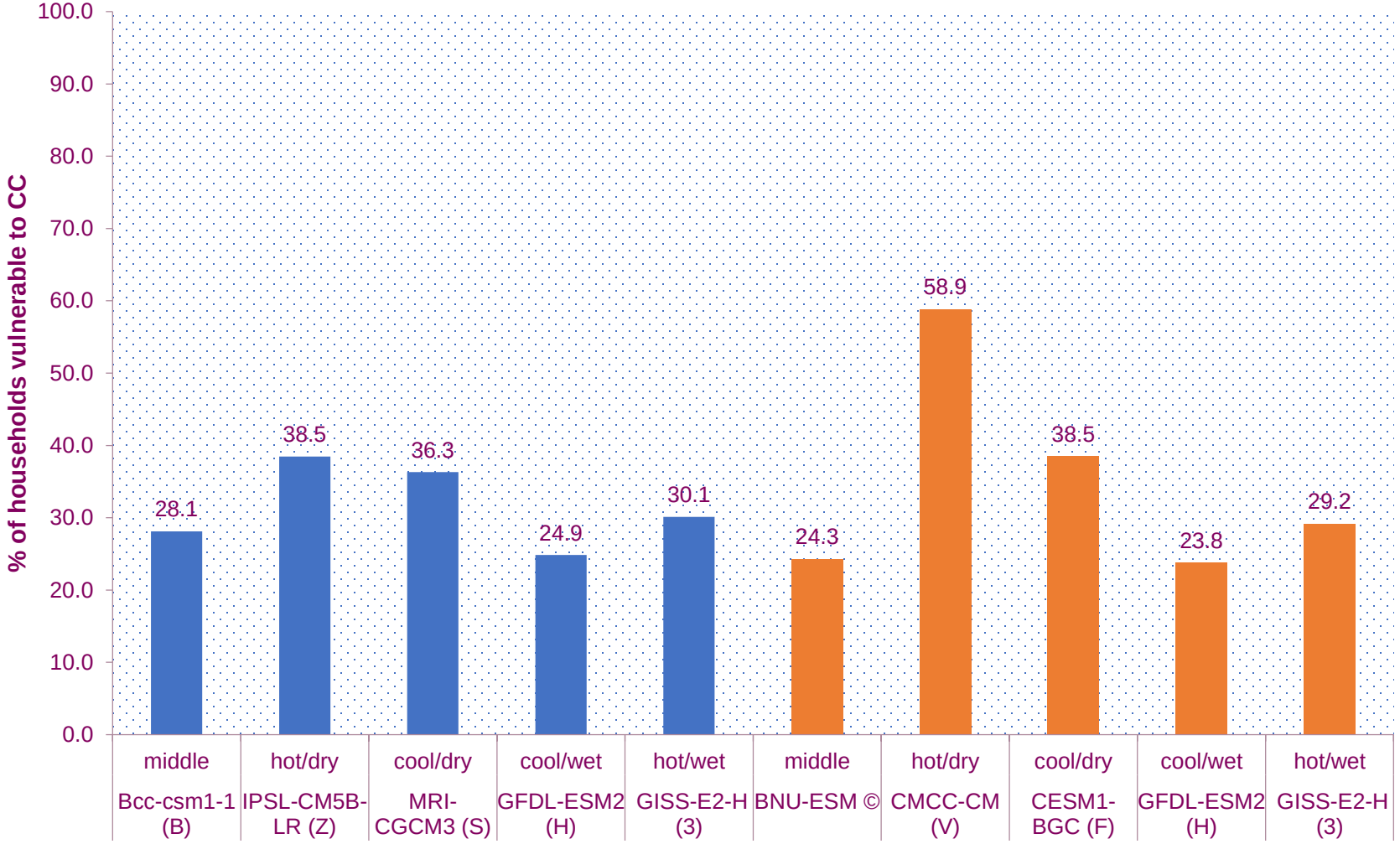
other colors represent the 5 GCMs selected.

What is the sensitivity of current production systems to climate change?

Crop simulation results (maize, millet & peanuts)

RCP	Crop Models	Maize	Millet	Peanuts
RCP 4.5	DSSAT	-29 to 11%	8 to 18%	24 to 77%
	APSIM	-16 to -4%	-16 to -7%	11 to 23%
RCP 8.5	DSSAT	-36 to -4%	-5 to 21%	-4 to 94%
	APSIM	-15 to -2%	-16 to -6%	14 to 35%

Proportion of households vulnerable to climate change in Nioro, Senegal



Key economic indicators of two GCMs by strata (DSSAT)

Climate Model	Type	Strata	Percent vulnerable HH	Net Impact (%)	Percent change NR	Percent Change PCI	Percent change Poverty
GFDL-ESM2	Cool / Wet	St1	27.60	30.74	41.5	21.1	-11.0
		St2	27.95	38.52	52.0	24.2	-11.4
		St3	21.88	33.84	45.2	23.4	-15.7
		St4	22.42	48.00	64.2	36.2	-19.2
		Ag	**23.83**	**38.46**	**51.5**	**25.9**	**-14.3**
CMCC-CM (V)	Hot /Dry	St1	57.10	-5.34	-7.3	-3.7	1.8
		St2	56.48	-5.37	-7.4	-3.4	1.0
		St3	60.83	-6.77	-9.3	-4.8	3.3
		St4	58.83	-6.63	-9.1	-5.1	2.0
		Ag	**58.92**	**-6.36**	**-8.7**	**-4.3**	**2.0**

Contribution of crops and livestock to total farm net returns

(RCP 8.5 – GCM GFDL-ESM2 - DSSAT)

Indicators	Strata	Maize	Peanuts	Millet	Livestock
% share of total farm net returns	St1	0	43	45	12
	St2	0	52	48	0
	St3	10	40	31	20
	St4	9	54	37	0
Average impact on net returns by activity	St1		1.87	1.14	0.89
	St2		1.94	1.07	
	St3	0.88	1.98	1.33	0.89
	St4	0.92	2.03	1.24	

Contribution of crops and livestock to total farm net returns

RCP 8.5 - **GCM CMCC-CM** - DSSAT

Indicators	Strata	Maize	Peanuts	Millet	Livestock
% share of total farm net returns	St1	0	43	45	12
	St2	0	52	48	0
	St3	10	40	31	20
	St4	9	54	37	0
Average impact on net returns by activity	St1		0.93	0.93	0.89
	St2		0.97	0.88	
	St3	0.62	0.94	0.97	0.89
	St4	0.62	0.94	0.94	

Main conclusions

- Climate change would have positive impact on Nioro farmers **livelihoods** in 4 out of 5 cases simulated. The exception would be under a hot and dry scenario;
- **Peanut**, as it is cultivated today, is not vulnerable to climate change and would almost always benefit from it and it is one of the most important crops in the system (because of its contribution to total farm net returns);
- **Maize**, as it is cultivated today, is highly vulnerable to climate change and would severely suffer from it ;
- **Millet**, as it is cultivated today, is moderately vulnerable to climate change and could either slightly benefit or suffer from it.

What is the impact of climate change on future production systems?

RAP4: Sustainability development – taking the green road

- Inclusive approaches in public policies are implemented alongside significant development of community initiatives and greater accountability of grassroots organizations.
- Good agro-ecological practices are mainstreamed leading to a gradual improvement of soil fertility in particular with better integration of crop-livestock production systems.
- The use of water storage technologies and better management induce increased availability and access to water.
- Decentralization policies are fully implemented in a context of improved human and social capital.
- Development of infrastructure, greater access to ICTs and the process of urbanization put some stress on labor availability, in particular for on farm activities
- Social and economic processes generate household segmentation along with greater labor demand for off-farm income.

RAP4: main drivers

RAP 4 : Sustainability development - Taking the green road			
Fertilizer prices	decrease	Small	20%
Fertilizer use	increase	small to medium	maize: fertilizer use varies in three subsamples: Fert=0 [10 kgN/ha]; 0<Fert≤15 [30 kgN/ha]; Fert>15 [40 kgN/ha]; Millet: fertilizer use from 0 to 15 kgN/ha
Subsidies	increase	Small	20%
Household size	decrease	Moderate	25%
Farm size	decrease	Small	20%
Off farm income	increase	Medium	20%
Herd size	decrease	small to medium	25%
Livestock productivity	increase	Moderate	30%

RAP5: Fossil fuel development

- Population growth and rapid urbanization lead policymakers to further develop infrastructure and rapidly raise agricultural productivity. The agricultural sector is a policy priority and must respond quickly to increased demand particularly from urban dwellers. Input subsidies, development of road networks and the revitalization of the peanut basin are key interventions.
- These policies and interventions are fulfilled without proper application of good and environmentally friendly agricultural practices, thus contributing to soil degradation and unsustainable use of water resources. Herd size and livestock productivity rise as a result of improved political support to the sector, better health protection programs, greater urban demand and the determination of pastoralists to seize these market opportunities.
- Development of the digital economy, mechanization of agriculture, and a strong energy demand exert a powerful influence on rural activities. Household size decreases along with fragmented farms. Stronger and better road networks increase employment opportunities outside agriculture.

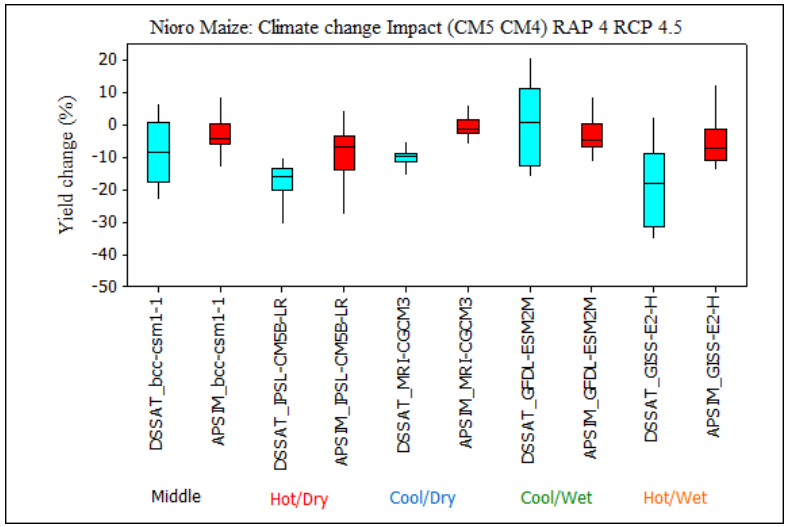
RAP5: main drivers

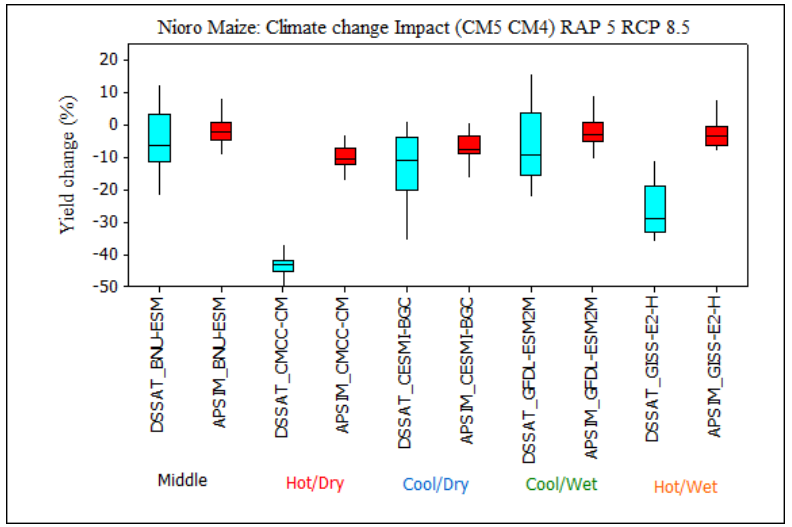
RAP 5: Fossil fuel development			
Fertilizer prices	Decrease	medium to large	60%
Fertilizer use	Increase	Large	maize: fertilizer use varies in three subsamples: Fert=0 [20 kgN/ha]; 0<Fert≤15 [30 kgN/ha]; Fert>15 [60 kgN/ha]; millet: fertilizer use from 0 to 15 kg/ha
Subsidies	Increase	medium to large	60%
Household size	Decrease	Medium	35%
Farm size	decrease	Medium	50%
Off farm income	Increase	medium to large	50%
Herd size	Decrease	Medium	30%
Livestock productivity	Increase	medium to large	40%

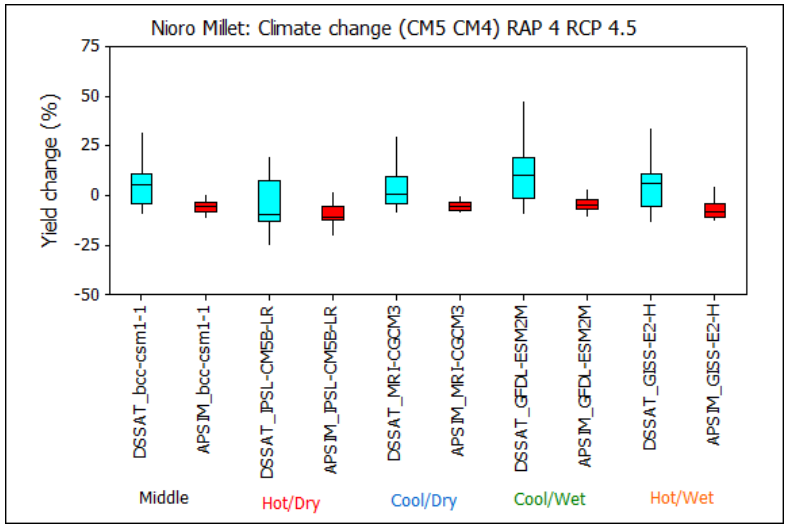
Price trends to 2050 (results from Impact Model)

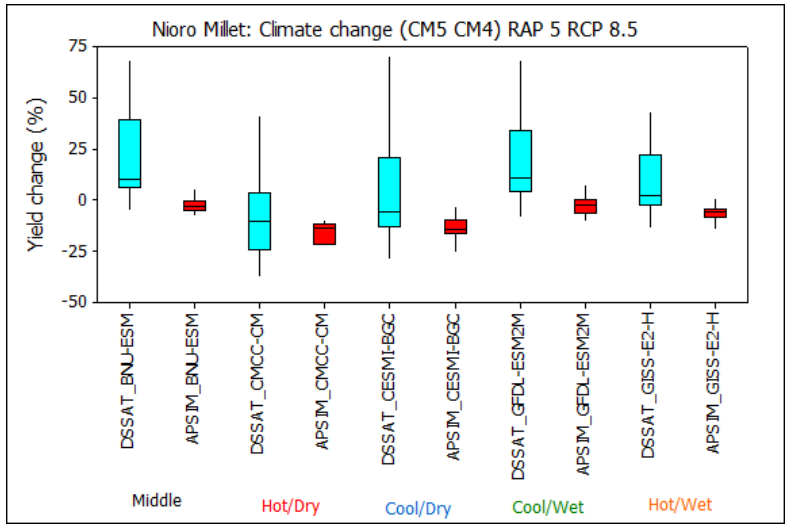
	System 1	System 2		System 1	System 2	
	No climate change	With climate change		No climate change	With climate change	
	SSP1 /RAP4	SSP1 /RAP4		SSP3/RAP5	SSP3/RAP5	
Crops	B1trend50m	F1trend50m	F1/B1	B2trend50m	F2trend50m	F2/B2
Maize	1.506	1.596	1.060	1.367	1.566	1.145
Peanuts	1.087	1.446	1.331	1.375	1.974	1.435
millet	0.968	1.208	1.249	1.387	1.777	1.281

Crop simulation results (maize & millet)

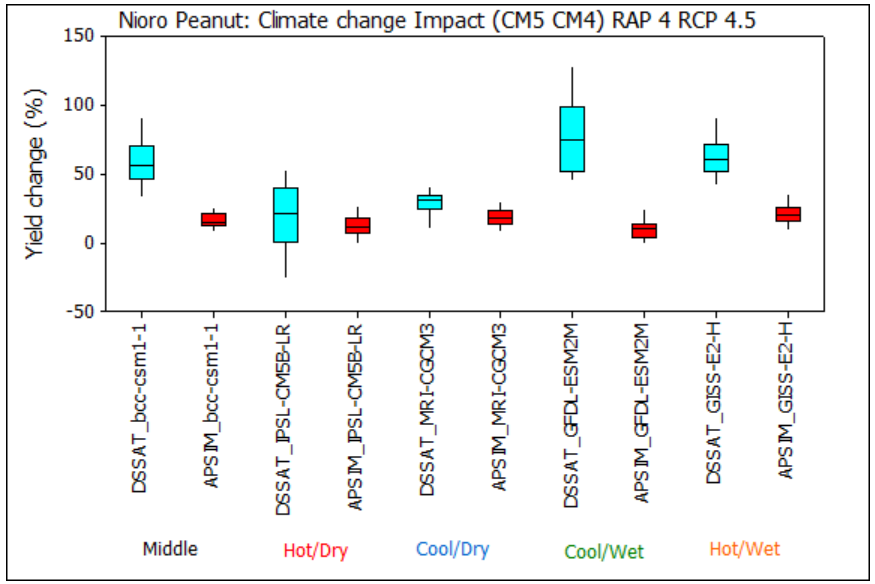


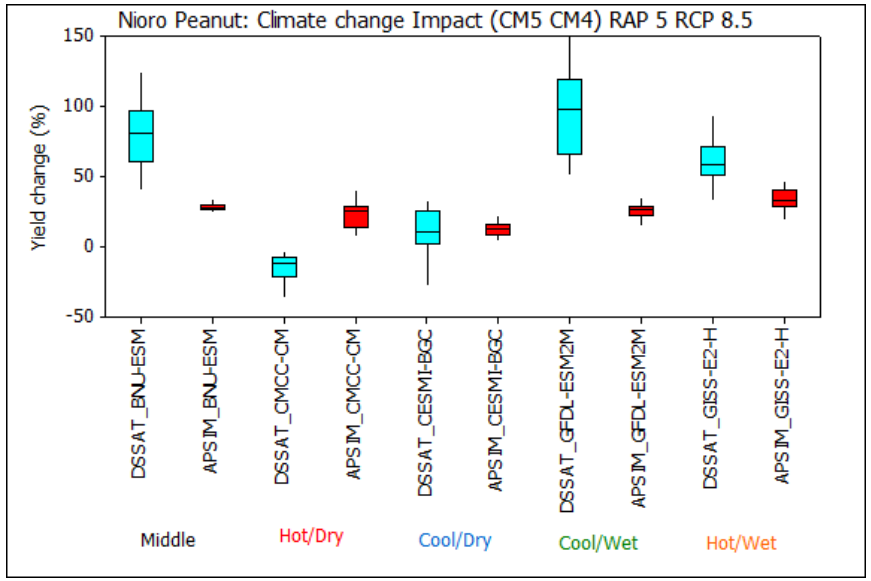




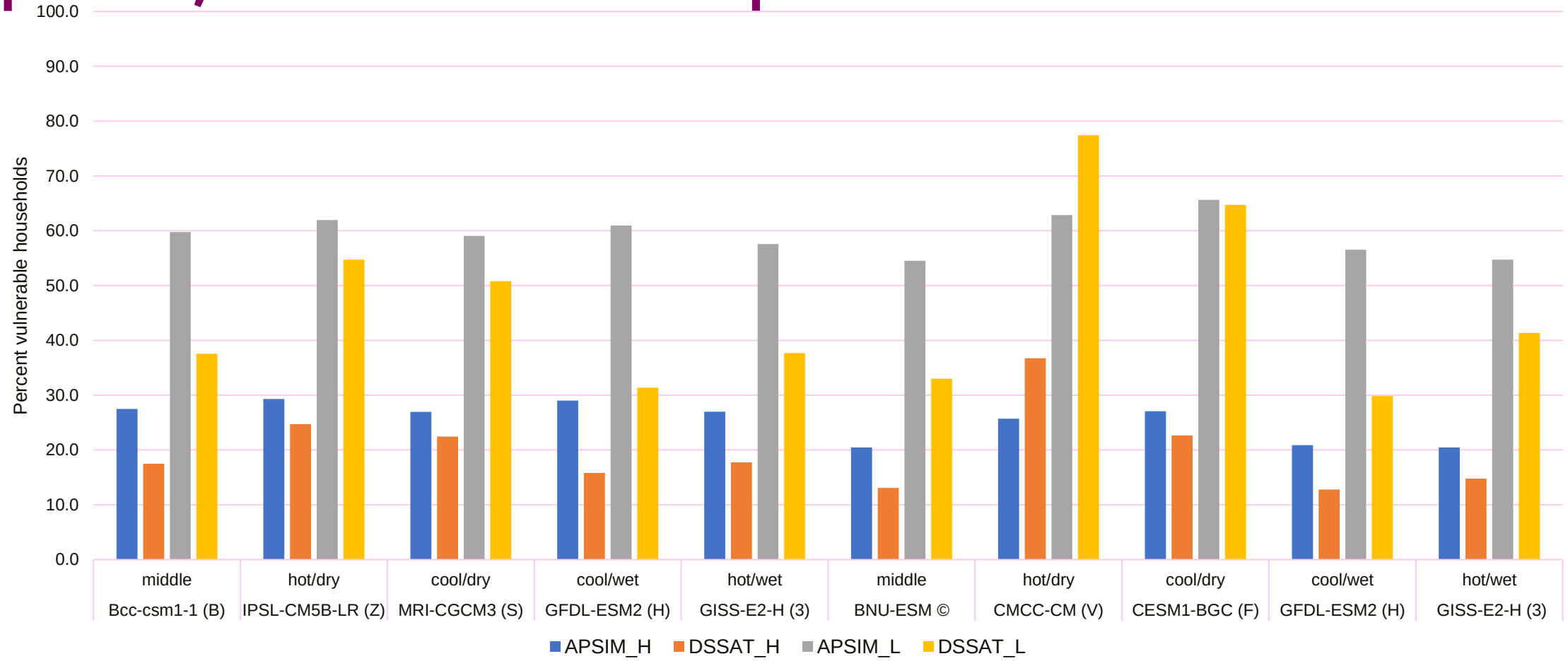


Crop simulation results (peanuts)

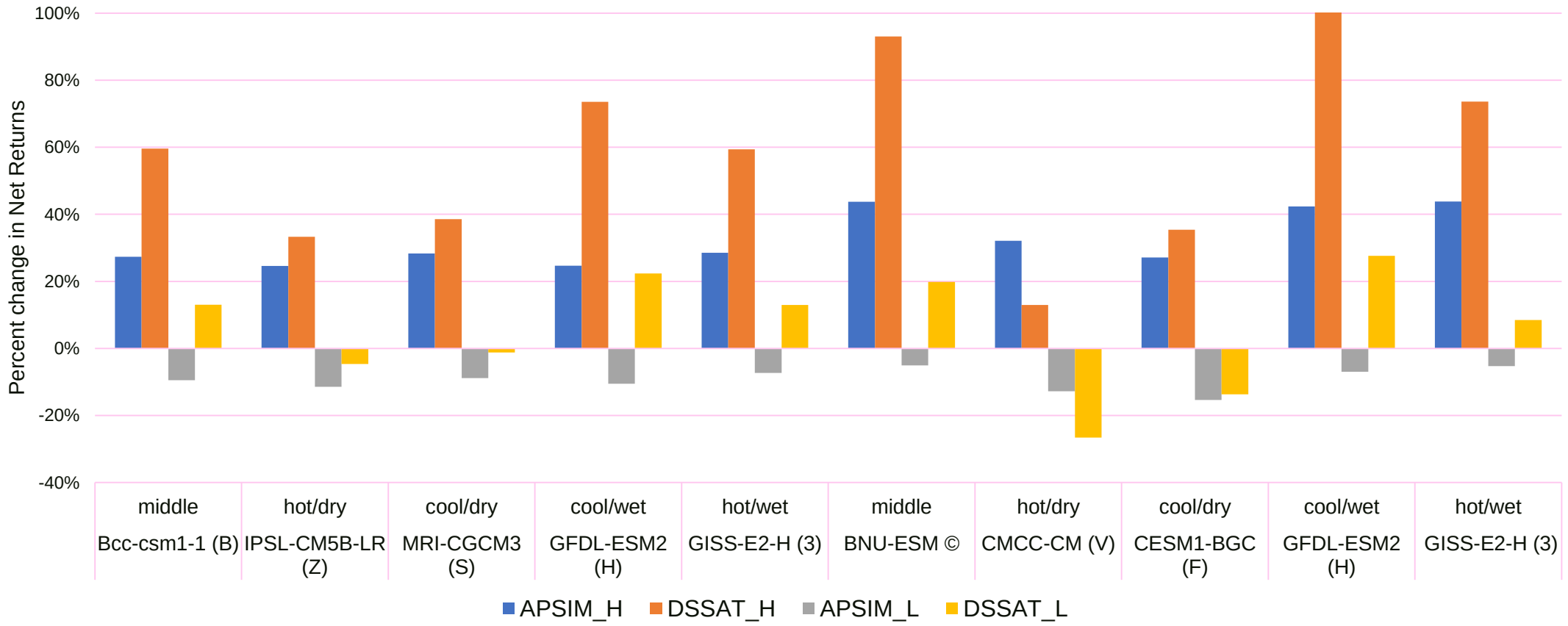




Percent vulnerable households under different prices, climate and crop models



Percent change in net farm returns under different prices, climate and crop models



Main conclusions

- In tomorrow's production systems and socio-economic conditions, climate change would have positive impact on Nioro farmers livelihoods in all cases simulated. However, with low prices, climate change would have a negative impact on Nioro farmers' livelihoods in most cases;
- Within these systems and under higher input levels, **maize** continues to suffer from climate change;
- Meanwhile, **millet** remains relatively unaffected by climate change and could either slightly benefit or suffer from it;
- **Peanut** still almost always benefits from climate change but it is susceptible to price changes which can impact farmers' livelihoods;
- Positive benefits from peanuts and higher prices may lead to land reallocation in favor of this crop with some implications for food security.

Policy implications

- Given peanuts' weight in the agricultural sector, its economic interrelations with other sectors and its relative protection against climate change, current and future policies should be more favorable to this export commodity.
- The Government should also anticipate the negative effects of aflatoxin by taking bold control measures. A reduction in the prevalence of aflatoxin will have positive effects on both health and international economic exchanges.
- Adaptation measures must take into account the reality of groundnuts while preserving small producers from the negative effects of climate on cereals. Future measures should also consider possible developments in production systems.
- Overall, policies should be mindful of the effects of prices which would worsen climate change effects if they take a downward trend.

THANK YOU

For further information please contact Dr. Ibrahima Hathie (ihathie@ipar.sn)
or visit (www.ipar.sn / www.agmip.org)

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