Agricultural Climate Change Impacts on Moroccan Agriculture and the Economy Including an Analysis of the Impacts of the « Plan Maroc Vert (PMV) »

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- Motivation & Objectives

- Moroccan economy: Stylized facts
  - Agriculture and climate in Morocco

- Analytical approach
  - The Morocco computable general equilibrium (CGE) model

- Description of data and scenario analysis
  - Data and Regionalization structure
  - Discussion of climate change impact scenarios

- Results & Analysis

- Conclusion

- Important backward and forward linkages: climate change → Agriculture → Rest of the economy → Agriculture, etc.

- Climate change impact studies on the agricultural sector in Morocco limited:
  - Few studies
  - Data not up-to-date

- Need for quantification of climate change impacts on the economy for policymakers

Regional assessment of climate change impacts on the agricultural sector in Morocco and its economy-wide linkages by:

▫ Accounting for the interregional dynamics of climate change at the level of the administrative and economic regional unit

▫ Using well-established climate scenarios for Morocco, with and without adaptation

- Share of agriculture in
  - GDP is 19% (15% crop production and 4% food processing)
  - Total employment is 43%
  - Total rural employment is 78%

- Agricultural production dominated by rainfed production systems
  - Irrigated land represents only 11% of total agricultural land
  - Cereals occupy 68% of total arable land

- Substantial share in trade
  - Food exports 23% of total merchandise exports
  - Food imports 11% of total merchandise import

Agriculture and Climate in Morocco

Evolution of agricultural GDP and per capita agricultural GDP in Morocco (1965-2009)
Source: Authors' adaptation (based on World Bank Data, 2010)
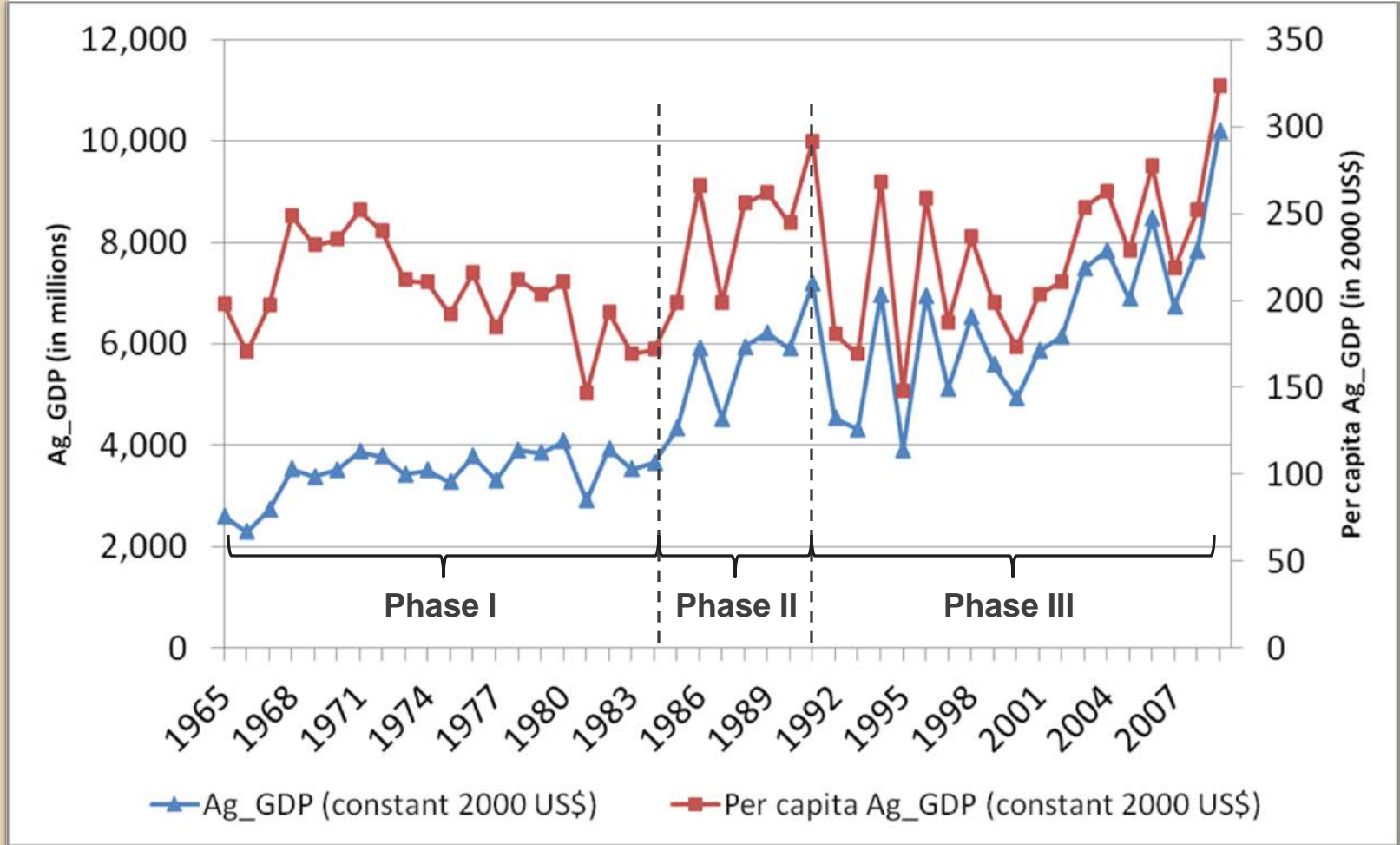
- Computable general equilibrium (CGE) model
  - Based off IFPRI's general framework (Logfren at al., 2002) and adapted by Dudu and Cakmak (2010)

- Captures the Moroccan economy through 30 production sectors, producing 30 commodities
  - Agricultural production (10 activities), livestock (4 activities)
  - Forestry & Fishery
  - Industry and manufacture (including Food processing) (12 activities)
  - Services (2 activités)

- 2 representative households (rural and urban)

- Government accounts and Rest of the World (ROW)

- Production is modeled based on the profit-maximization assumption, subject to a production technology
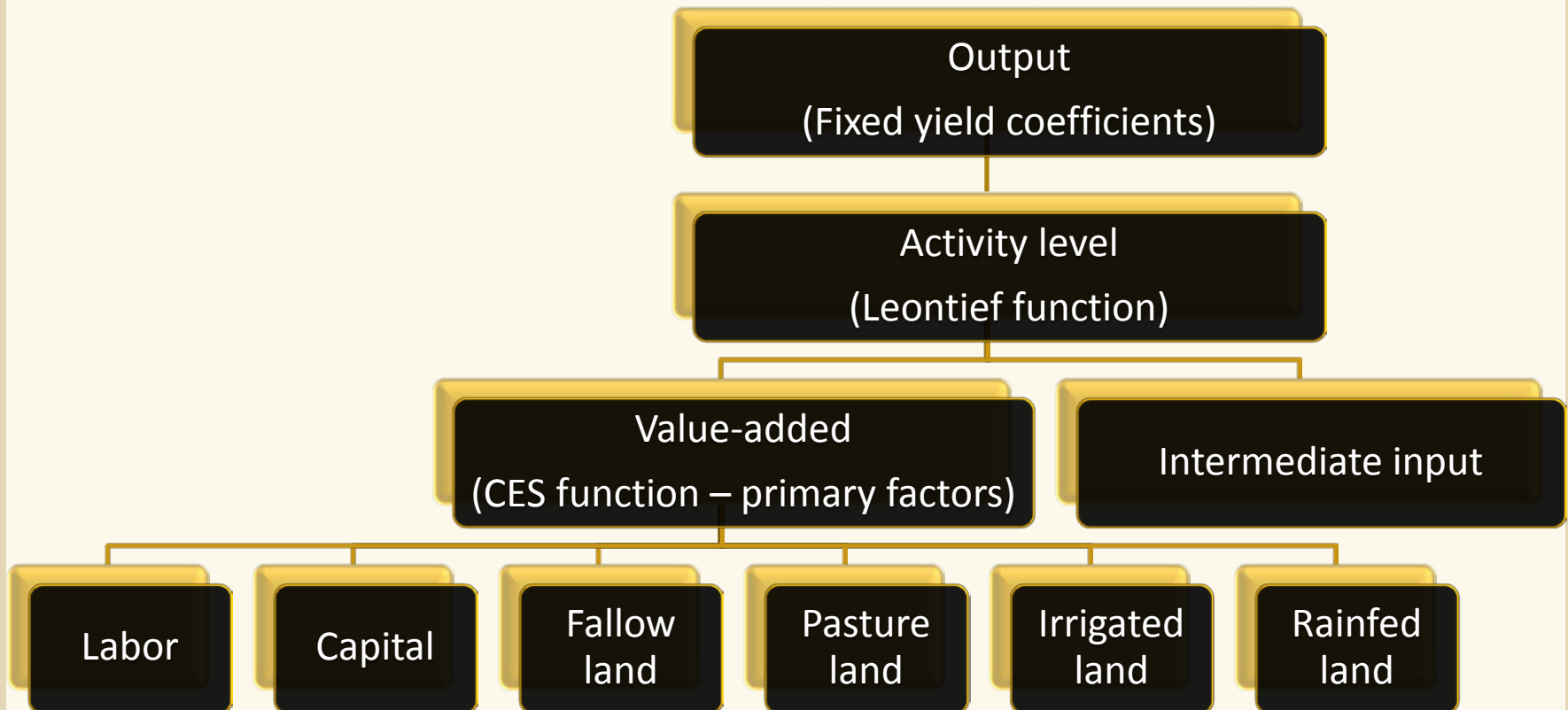
- Households maximize utility s.t. a consumption expenditure constraint and modeled via a Linear Expenditure System (LES)
  - Utility function is of the "Stone-Geary" genre

- Government collects taxes and receives transfers from other institutions;
  - No behavioral modeling of government

- Closure assumptions

  □ Consumer Price Index (CPI) is set to be the numeraire; whereas the Index of domestic producer prices (DPI) is flexible

  □ Exchange rate is flexible and foreign savings are fixed

  □ Share of investment is fixed

  □ Lastly, government savings fixed, with direct tax rates flexible

- The base data is from a social accounting matrix (SAM) developed by the Dr. Rachid Doukkali of IAV/Hassan II (base year 2003);
    - ▫ Modified to account for the adopted sectoral aggregation in the model, i.e. 30 sectors producing 30 commodities

- Regional disaggregation is based on the administrative and economic regions (AERs) in Morocco

Data and Regionalization structure

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15 Administrative and Economic Regions (AERs)

Legend	Region	Legend	Region
	Tanger-Tétouan		Chaouia-Ouardigha
	Gharb-Cherarda-Beni Hsan		Grand Casablanca
	L'Oriental		Rabat-Salé-Zemmour-Zaër
	Meknes-Tafilalet		Taza-Taounate-Al Hoceima
	Tadla-Azilal		Fès-Boulemane
	Souss-Massa-Draa		Guelmim-Esmara*
	Marrakech-Tensift-Al Haouz		Laayoune-Boujdour-Sakia El Hamra*
	Doukkala-Abda		Oued Eddahaab – Lagouira*

Source: Authors adaptation

- Agricultural crop production is regionalized based on regional production shares computed from Agricultural Census on Major Crop Production (2002-2003);

- For the rest of the production sectors, we used national statistics from:
  - Agence de Développement Agricole (ADA);
  - Haut Commissariat au Plan (HCP);
  - Office Nationale de l'Electricite (ONE);
  - Office des Changes (OC);
  - Office Nationale des Pêches (ONP);
 - Etc.

Climate change impacts: Data and Scenarios

- Climate-induced yield impacts obtained from the WB/Morocco/FAO study (2010)
- Estimated for 50 crops under 4 time horizons and 2 SRES scenarios:
  - "Baseline"(1976-2006), "2030" (2011-2040), **"2050" (2041-2070)** and "2080" (2071-2099);
  - A2 and B2 using the HadCm3 GCM model
- Yield impacts downscaled to a 10 km x 10 km grid-cells compatible with the AEZs in Morocco;
  - Favorable "FAV", Intermediate "INTERM", Unfavorable-Oriental "DEF-Or", Unfavorable-South "DEF-Sud", Mountain "MONT", and Sahara "SAH";
- Impacts were estimated with and without CO_2 fertilization effects, with confidence intervals capturing the average impact and the 10th and 90th percentiles of yield impacts;
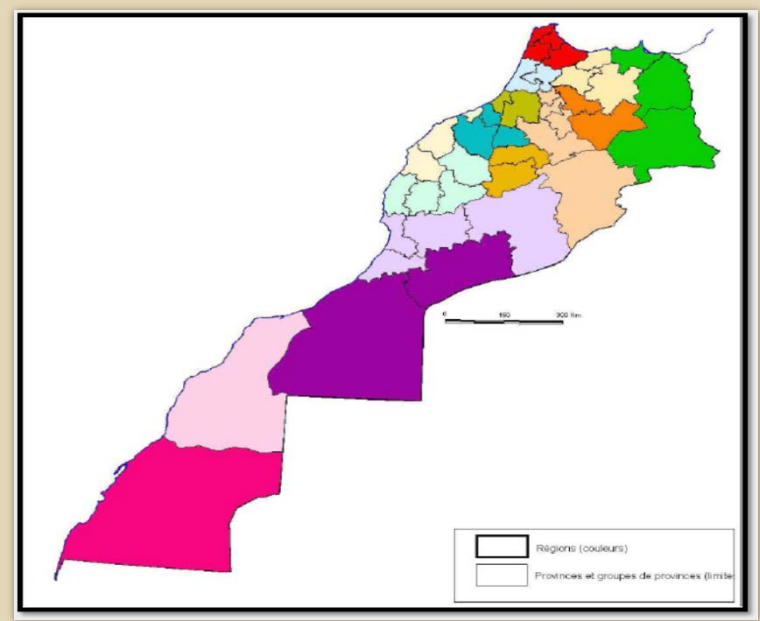
Climate change impacts: Data and Scenarios

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6 AEZs
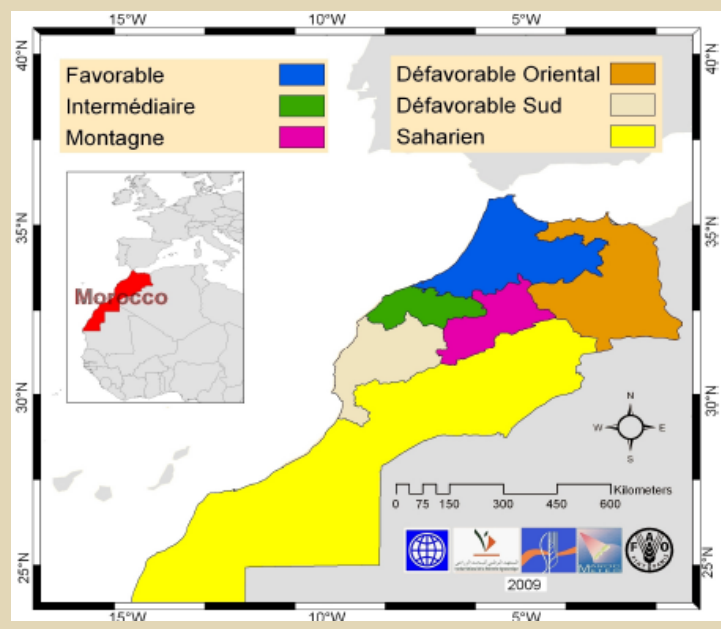
15 AERs

Summary of scenario analysis

Table 5: Description of scenarios analysis

Scenario	Description
A2_noCO2	Projected yield impacts by 2050 under SRES A2, with no CO2 fertilization effect and no adaptation
B2_noCO2	Projected yield impacts by 2050 under SRES B2, with no CO2 fertilization effect and no adaptation
A2_wCO2	Projected yield impacts by 2050 under SRES A2, with CO2 fertilization effect and no adaptation
B2_wCO2	Projected yield impacts by 2050 under SRES B2, with CO2 fertilization effect and no adaptation
A2_noCO2_PMV	Projected yield impacts by 2050 under SRES A2, with no CO2 fertilization effect and with PMV adaptation
B2_noCO2_PMV	Projected yield impacts by 2050 under SRES B2, with no CO2 fertilization effect and with PMV adaptation
A2_wCO2_PMV	Projected yield impacts by 2050 under SRES A2, with CO2 fertilization effect and with PMV adaptation
B2_wCO2_PMV	Projected yield impacts by 2050 under SRES B2, with CO2 fertilization effect and with PMV adaptation

Source: Authors' adaptation

The PMV Strategy

- Assistance and encouragement of private investment
  - Public-Private partnerships (e.g. privatization of public and collectivity land, etc.)

- Modernization of distribution circuits and enhanced integration with local/international markets

- Assistance in reconversion of land crop tenure from cereals to high value-added crops (e.g. olive, tree fruits, etc.)

- Intensification of production through better access to agricultural inputs (e.g. fertilizer) and seed technology

- Assistance in adoption of modern irrigation technology

Summary impact of productivity targets in the PMV strategy for major crops

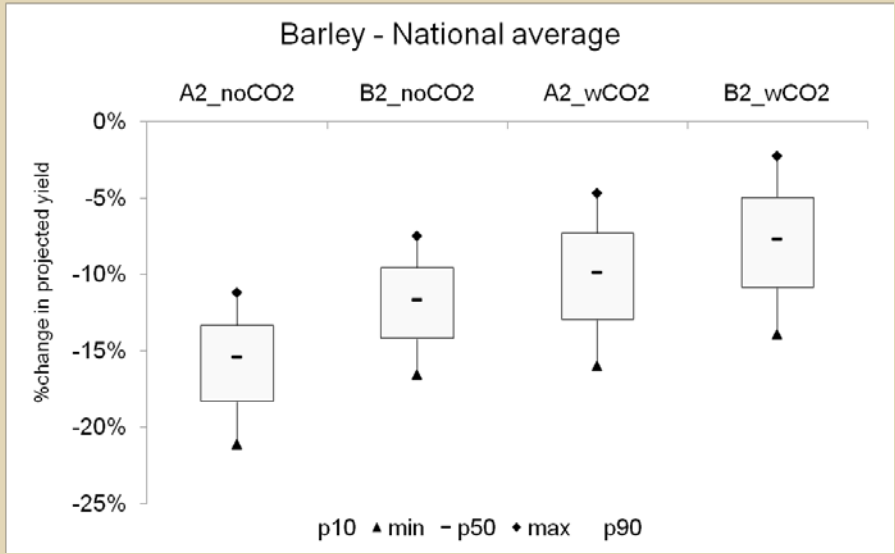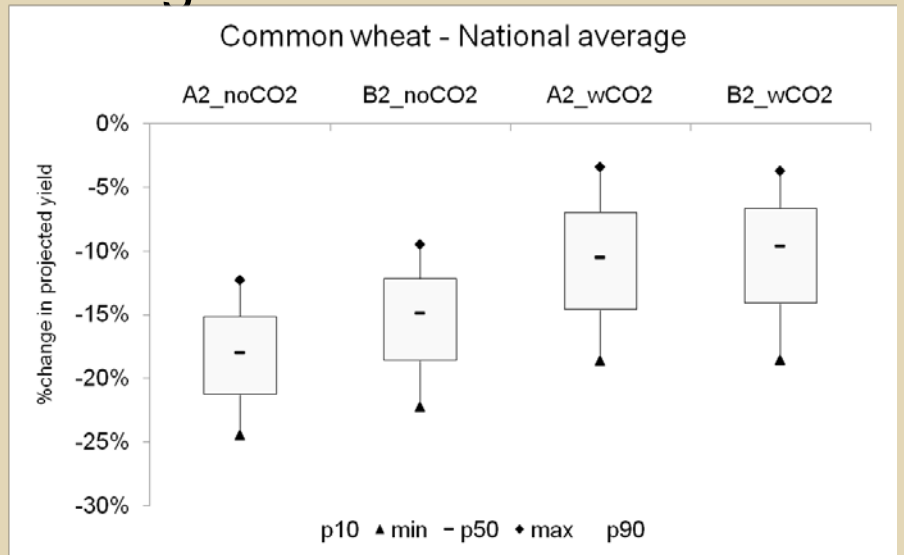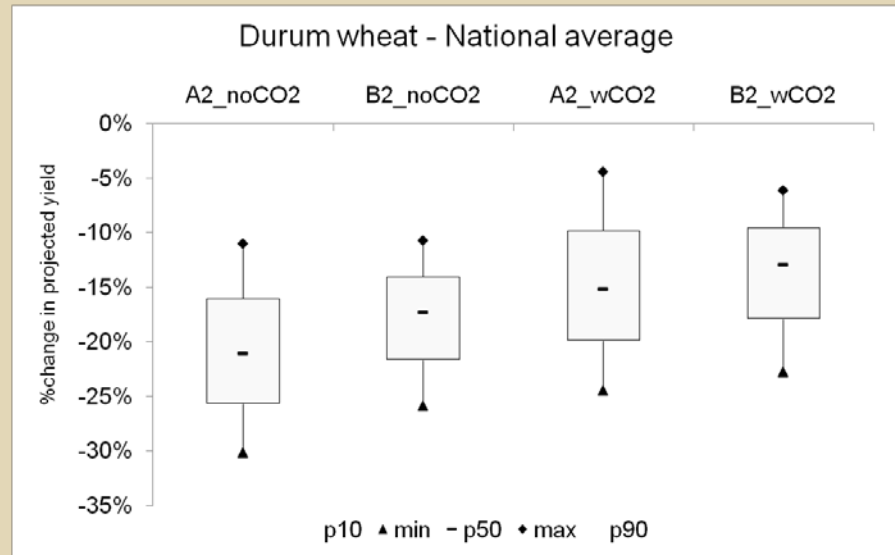## Table 6: Projected yield impacts of the Plan Maroc Vert (PMV) for strategic crops by region

Code	Regions	PMV - Crop sectors targeted			
		Cereals	Vegetables	Olives	Citrus
TR2	Souss-Massa-Draa	n.a.	47%	59%	33%
TR3	Gharb-Cherarda-Bni Hsan	73%	n.a.	63%	67%
TR4	Chaouia-Ouardigha	69%	68%	91%	n.a.
TR5	Marrakech-Tensift-El Haouz	52%	n.a.	80%	30%
TR6	L'Oriental	n.a.	n.a.	26%	96%
TR7	Grand Casablanca	86%	80%	n.a.	n.a.
TR8	Rabat-Sale-Zemmour-Zaer	87%	68%	83%	n.a.
TR9	Doukkala-Abda	93%	62%	n.a.	n.a.
TR10	Tadla-Azilal	38%	n.a.	79%	50%
TR11	Meknes-Tafilalet	80%	n.a.	78%	n.a.
TR12	Fes-Boulemane	93%	57%	92%	n.a.
TR13	Taza-Taounate-Al Hoceima	85%	n.a.	44%	77%
TR14	Tanger-Tetouan	n.a.	n.a.	53%	79%

Source: Authors' adaptation (Data source: Agence pour le Développement Agricole
http://www.ada.gov.ma/en/Plan_Maroc_Vert/plan-maroc-vert.php)
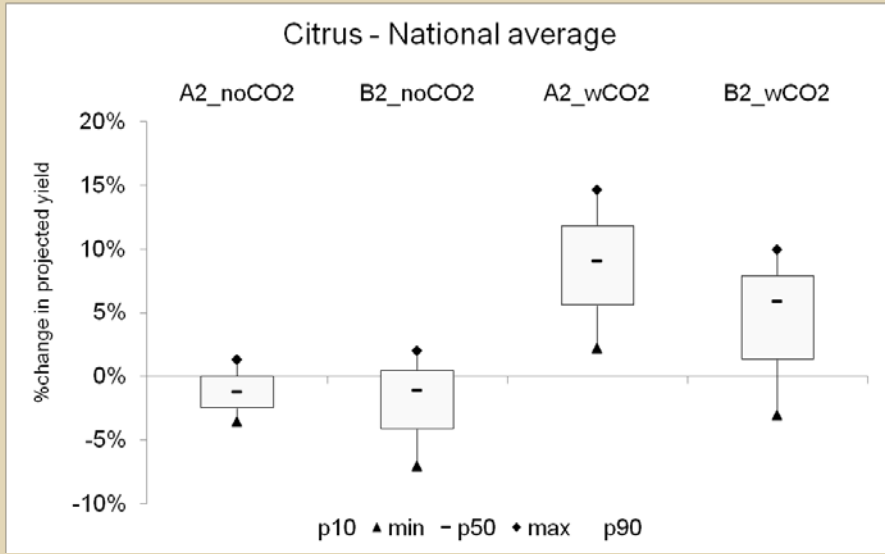
Climate change impacts: Projected yields

Projected yield impacts for selected crops by SRES scenarios – national average

Projected yield impacts for selected crops by SRES scenarios – national average
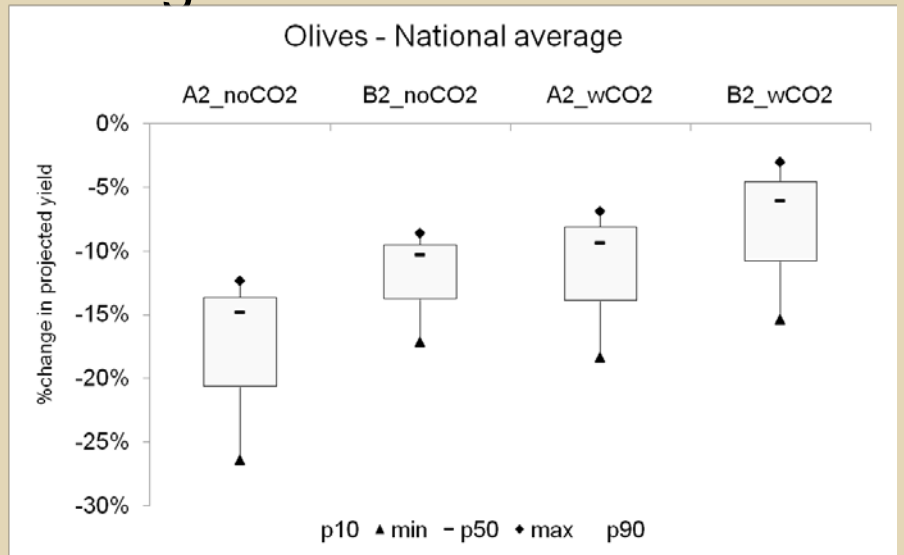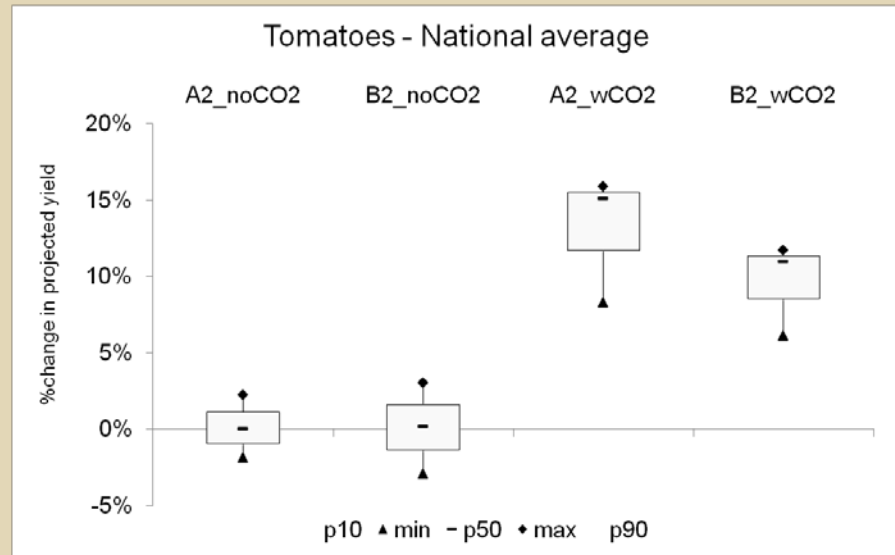
Macroeconomic accounts – No adaptation (%Change from BASE)

	BASE	A2_noCO2		
		Low	**Med**	**High**
Consumption - C	272,986	-3.37%	-1.84%	-0.97%
Investment - I	133,622	-2.88%	-1.54%	-0.84%
Government - G	85,485	-1.91%	-1.01%	-0.53%
Exports - X	139,736	-0.85%	-0.44%	-0.22%
Imports - M	-153,254	-0.78%	-0.40%	-0.20%
Gross Domestic Product (GDP)	478,574	-3.07%	-1.66%	-0.88%

- Climate change has the potential to act as a drag on the economy as a whole
  - Agricultural sector and food processing industry particularly affected due to strong linkages between the two

- Impacts can be significant, especially under the worst case scenario

- All macro indicators affected negatively → contraction in the overall level of economic activity

Impact of historical droughts on gross domestic product (GDP) – by sector

Year	GDP (current US$)	Value added (current US$)			
		Agriculture	Industry	Manufacturing	Services
1980	18,820,809,836	3,468,322,918	5,823,121,475	3,166,717,472	9,474,290,346
1981 (Drought)	15,280,300,833	1,973,145,409	5,205,421,186	2,764,862,827	8,102,995,075
%Change	-18.8%	-43.1%	-10.6%	-12.7%	-14.5%
1998	40,021,694,631	7,175,553,492	9,831,727,514	6,136,031,660	18,474,314,520
2000 (Drought)	37,020,609,825	4,916,337,286	9,575,098,814	5,744,965,180	18,406,644,081
%Change	-7.5%	-31.5%	-2.6%	-6.4%	-0.4%

Source: Authors adaptation (data source: World Bank, 2012)

- Severe droughts have had historically similar impacts on the economy
  - e.g. in the 1981 drought, GDP falls by -19% with agriculture -43%, industry -11%, manufacturing -13% and services -14%
- Economy becoming more resilient with more decoupling of rest of the economy from the agricultural sector

Sectoral output (valued at output prices) – No adaptation (%Change from BASE)

	BASE	A2_noCO2		
		Low	Med	High
Agriculture	75,813	-4.26%	-2.07%	-0.74%
Livestock	34,380	-1.74%	-0.47%	0.06%
Forestry&Fishery	10,162	-4.54%	-2.58%	-1.48%
Dairy	5,856	-3.78%	-2.08%	-1.10%
Food processing	166,078	-4.74%	-2.54%	-1.38%
Industry and manufacture	544,386	-3.06%	-1.67%	-0.99%
Services	592,030	-3.83%	-2.09%	-1.14%

Impact mostly negative on all sectors

Households income – No adaptation (%Change from BASE)

	BASE	A2_noCO2		
		Low	**Med**	**High**
National_Urban	344,485	-3.58%	-1.92%	-1.03%
National_Rural	95,838	-3.69%	-1.98%	-1.06%
National	440,323	-3.60%	-1.94%	-1.04%

Contractionary effects of climate change on the economic activity → Declining returns of factor of production due to lower productivity as captured by lower wages, rents → Decline in household income, coupled with price increases → declining household consumption

Sectoral impacts – Agriculture, No adaptation

		BASE	A2_noCO2		
			Low	**Med**	**High**
Agriculture		**75,813**	**-4.26%**	**-2.07%**	**-0.74%**
Employment	Capital	26,771	-0.33%	0.15%	0.32%
	Labor	6,151	-0.09%	0.26%	0.48%
	LandIr	7,972	-1.20%	-0.20%	0.44%
	LandRf	11,153	-0.18%	0.39%	0.77%
Trade	Exports	13,810	-8.75%	-4.41%	-1.48%
	Imports	13,739	47.82%	26.50%	14.44%

Sectoral impacts – Food processing, No adaptation

		BASE	A2_noCO2		
			Low	Med	High
Food processing		**166,078**	**-4.74%**	**-2.54%**	**-1.38%**
Employment	Capital	17,104	-9.31%	-5.21%	-2.86%
	Labor	5,029	-8.37%	-4.65%	-2.61%
Trade	Exports	6,109	-9.80%	-5.25%	-3.33%
	Imports	10,643	1.27%	0.56%	0.33%

- Substantial impact on agriculture and food processing
  - Output falls by -0.8% to -4.3% for agriculture (crop production) and -1.4% to -5% for food processing
- As marginal productivity of main factors of production falls
  - For labor and rainfed land in agriculture → substitute away for more capital and irrigated land
  - For food processing → capital and labor intensive, thus lower productivity induces lower demand
- Severe impacts on trade accounts
  - Exports fall by -9% and -10%; whereas imports increase by 48% and 1.3% for both sectors respectively under the worst case scenario

Macroeconomic accounts – with adaptation (%Change from BASE)

	BASE	B2_wCO2		
		Low	**Med**	**High**
Consumption - C	272,986	1.76%	2.95%	3.62%
Investment - I	133,622	0.62%	1.51%	2.00%
Government - G	85,485	0.68%	1.27%	1.62%
Exports - X	139,736	2.18%	2.70%	2.94%
Imports - M	-153,254	1.99%	2.46%	2.69%
Gross Domestic Product (GDP)	478,574	1.30%	2.33%	2.91%

Sectoral output – with adaptation (%Change from BASE)

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Industry and manufacture	544,386	0.76%	1.50%	1.90%
Services	592,030	1.33%	2.48%	3.14%

Sectoral impacts – Agriculture, with adaptation

		BASE	B2_wCO2		
			Low	Med	High
Agriculture		**75,813**	**5.57%**	**7.65%**	**8.68%**
Employment	Capital	26,771	-0.50%	-0.46%	-0.56%
	Labor	6,151	0.01%	0.19%	0.20%
	LandIr	7,972	14.91%	17.94%	19.40%
	LandRf	11,153	11.26%	13.03%	13.90%
Trade	Exports	13,810	13.69%	19.01%	21.68%
	Imports	13,739	14.93%	1.80%	-6.10%

Sectoral impacts – Food processing, with adaptation

		BASE	A2_noCO2		
			Low	Med	High
Food processing		**166,078**	**0.56%**	**2.00%**	**2.85%**
Employment	Capital	17,104	1.41%	4.43%	6.24%
	Labor	5,029	1.79%	4.48%	6.09%
Trade	Exports	6,109	0.77%	3.07%	4.48%
	Imports	10,643	2.94%	2.72%	2.50%

- Positive impact on agriculture and food processing
  - Output increases by 6% to 9% for agriculture (crop production) and 0.6% to 3% for food processing
- Driven primarily by projected yield gains under the PMV strategy
  - Higher yields → higher productivity for factors of production
- As factor productivity increases → demand in each sector increases for factor according to factor-intensity
  - In agriculture → decrease in demand for capital as demand for labor, irrigated land and rainfed land become more productive

- Substantial improvement in the trade balance

  - Agricultural trade improves substantially as exports surge increasing by 14% to 22%

  - Food processing follows a similar pattern where exports increase by 1% to 4.5%

- Climate change impacts, under a no-adaptation scenario, can be negative and substantial
  - Agriculture and food processing particularly affected

- Impacts are large enough to act as drag on the overall level of economic performance

- The PMV strategy could hold some elements of answer to adapt to projected climate change impacts
  - But, overall success will depend highly on the feasibility of the investment program and the ability to translate the productivity targets into reality(???)