WIDER Working Paper 2014/083

Climate change impacts on Moroccan agriculture and the whole economy

An analysis of the impacts of the Plan Maroc Vert in Morocco

Ismail Ouraich and Wallace E. Tyner*

April 2014

Abstract: The paper provides estimates of economic impacts of climate change, compares these with historical impacts of drought spells, and estimates the extent to which the current Moroccan agricultural development and investment strategy, the Plan Maroc Vert, helps in agricultural adaptation to climate change and uncertainty. We develop a regionalized Morocco Computable General Equilibrium model to analyse the linkages of climate-induced productivity losses (gains) at the level of administrative and economic regions in Morocco. Yield projections are obtained from the joint-study by the Moroccan Ministry of Agriculture and Fisheries and the World Bank, in collaboration with the National Institute for Agricultural Research, the Food and Agriculture Organization of the United Nations, and the Direction of National Meteorology. We model the climate change impacts as productivity (or yield) shocks in the agricultural sector, and which are region- and crop-specific. The yield projections are for 2050, and introduced with respect to a 2003 baseline. With no adaptation, GDP impacts range from -3.1 per cent (worst-case scenario) to +0.4 per cent (best case scenario). The decline in GDP under the worst-case scenario results from a general contraction in economic aggregates. Accounting for the adaptation measures in the Plan Maroc Vert, the GDP impacts from climate change are reduced and range from -0.3 per cent to +3 per cent. Nonetheless, the adaptation potential of the Plan Maroc Vert is based upon the assumption of achieving the identified productivity-enhancement targets, and which remains questionable.

Keywords: CGE models, agricultural policy, adaptation, climate change, SRES scenarios, uncertainty
JEL classification: O13, Q10, Q54

Acknowledgements: This paper is one of a series of studies on assessing the climate change impact on economic development opportunities in North Africa. The authors gratefully acknowledge the financial contribution of the World Institute for Development Economics Research of the United Nations University (UNU-WIDER). Also, we express our gratitude for Rachid Doukkali who generously provided us with the Social Accounting Matrix (SAM) of Morocco for 2003 and which serves as the baseline for the CGE model. We extend our gratitude to Hasan Dudu for his valuable feedback and insights.

*Purdue University, corresponding author: iouraich@purdue.edu

This study has been prepared within the UNU-WIDER project on The Middle East, North Africa, and Climate Change, directed by Imed Drine and Wallace E. Tyner.

ISSN 1798-7237 ISBN 978-92-9230-804-9 https://doi.org/10.35188/UNU-WIDER/2014/804-9

Typescript prepared by Minna Tokkari at UNU-WIDER.

UNU-WIDER gratefully acknowledges the financial contributions to the research programme from the governments of Denmark, Finland, Sweden, and the United Kingdom.

The World Institute for Development Economics Research (WIDER) was established by the United Nations University (UNU) as its first research and training centre and started work in Helsinki, Finland in 1985. The Institute undertakes applied research and policy analysis on structural changes affecting the developing and transitional economies, provides a forum for the advocacy of policies leading to robust, equitable and environmentally sustainable growth, and promotes capacity strengthening and training in the field of economic and social policy-making. Work is carried out by staff researchers and visiting scholars in Helsinki and through networks of collaborating scholars and institutions around the world.

UNU-WIDER, Katajanokanlaituri 6 B, 00160 Helsinki, Finland, wider.unu.edu

1 Introduction

The trend of agricultural productivity growth in the last decades has been tremendous in many ways, which helped to alleviate poverty and food insecurity in many areas (although there are still substantial differences across regions). This was primarily due to improved production systems and investments in crop and livestock breeding programmes. Nonetheless, climate change threatens to exacerbate the existing challenges faced by agriculture. The global population is estimated to reach nine billion by 2050, with the bulk of the increase occurring mostly in Africa and South Asia. Also, taking into account the accelerated demand for food and changes in dietary habits, the Food and Agriculture Organization (FAO) estimated that feeding the world population will require a 70 per cent increase in total agricultural production (FAO 2010).[1] Yet, the problem gets compounded as we take into consideration the threat of climate change to the stability and productivity of the agricultural sector. Numerous studies (Cline 2007; Fisher et al. 2005; IPCC 2007) have shown that the spectre of climate change is looming even bigger for regions already experiencing low and erratic productivity levels. For instance, it has been estimated that a warming of 2 °C could result in a 4 to 5 per cent permanent reduction in annual income per capita in Africa and South Asia (World Bank 2010).

In its latest report, the Intergovernmental Panel on Climate Change (IPCC) stated that the African continent is poised to be among the most vulnerable regions to climate change and climate variability, a situation that is aggravated by existing developmental challenges such as endemic poverty, complex governance, and institutional dimensions, as well as limited access to capital, infrastructure, and technology (IPCC 2007).[2] Reforms and modernization of the agricultural sector is paramount in order to adapt and/or mitigate the impacts of climate change and their linkages with current policy issues such as sustainable economic growth,[3] food security,[4] health, and malnutrition. Indeed, many countries in the continent already experience challenging climatic conditions that impact negatively to the prospects of agriculture. For example, it has been projected in some countries that yield reductions could reach as high as 50 per cent by 2020 (IPCC 2007).[5]

In recent years, the science of climate change achieved great strides in advancing our understanding of the bio-physical linkages of climate change. Enhancements of modelling capabilities provide more robust climate projections at the global level. In addition, recent modelling efforts in the area of crop model simulations provide better integration between the climate change science and the biophysical

---

[1] In terms of undernourished people in the world, the post-economic crisis levels remain very high in comparison with their levels 40 years ago, and even higher than the level that existed when the hunger-reduction target was agreed at the World Food Summit in 1996 (FAO 2010).

[2] Overall, this finding has been robust for all of the SRES scenarios included in the analysis, although minor differences in terms of projections exist among the different scenarios mainly driven by the different assumptions underlining each scenario.

[3] For example, the contribution of agricultural GDP varies from one country to the other, but is still significant where the average in the continent is 21 per cent (ranging from 10 to 70 per cent) (Mendelsohn et al. 2007)

[4] In 2006, food prices escalated into a surge of food price inflation around the world, with Africa being particularly hard hit, which experienced food riots. In the wake of the Financial Crisis of 2007-08, the FAO food price index rose by 27 per cent in 2007, and this increase persisted and even accelerated during the first half of 2008 (FAO 2009).

[5] It should be noted that these projections are quite differentiated from one country to the other, driven by the uncertainty in climate-induced productivity impacts on agriculture and their underlining assumptions, as well as by the economic structures characterizing each country in the African continent.

science of plant growth dynamics. Nonetheless, more analysis is needed on the economics of climate change. There are many factors that explain this slower development of economic impact analysis. Chief among them is the dependency upon reliable climate projections that could be fed into economic models to measure impacts at the socio-economic level, and evaluate policy mitigation and/or adaptation strategies. The early literature of economic impact assessment on climate change provided useful insights on the issue, but remained limited in scope and depth as it focused on highly aggregated unit of analysis (e.g. at the continental or sub-continental levels). Nonetheless, the current trend of the empirical literature displays a shift towards engaging in 'case-by-case' analyses at the country and/or sub-country level.

In this context, we use a computable general equilibrium (CGE) model to analyse the impacts of climate change at a refined geographical scale, with a focus on Morocco. First, we develop a set of yield projections using data from the study conducted by the World Bank (WB) and the Moroccan Ministry of Agriculture, Rural Development, and Fisheries (MPAM); in collaboration with the National Institute for Agricultural Research (INRA); the Food and Agriculture Organization (FAO); and the National Meteorology Authority (DMN) (Gommes et al. 2009). From this point forward, we will refer to the previous study as the WB/Morocco/FAO study for ease of reference. We assume the yield projections to represent productivity (or efficiency) shocks introduced exogenously to the model. In other words, they are modelled as shifts in the total factor productivity (TFP). The model is based on the International Food Policy Research Institute's (IFPRI) CGE templates (Lofgren et al. 2002) and the updated version by Dudu and Cakmak (2011). This will allow us to map out region-specific economic impacts of climate-driven productivity impacts on crop yields. Finally, we investigate the potential for adaptation in the Plan Maroc Vert (PMV) strategy being implemented at the regional level in Morocco.

The paper will be organized as follows: Section 2 discusses the literature of CGE analysis related to economic impact assessment of climate change. In Section 3, we present our methodological approach and data sources. Section 4 summarizes key findings and results, and Section 5 provides a summary conclusions.

2 Climate change impact assessment and CGE analysis

The recent literature using CGE models to analyse climate change impacts and adaptation linkages has taken two directions. The first one is based on country-based CGE models that focus on domestic impacts, which allows for a more detailed analysis in terms of mapping out the latter impacts to the domestic economy. The second is based upon a multi-region structure at the global level (e.g. Global Trade Analysis Project model), and where the focus is directed at analysing inter-regional impacts mainly driven through international trade linkages.

Horridge et al. (2005) use a bottom-up CGE model for Australia to analyse the impact of the 2002-03 drought. The model was coined TERM (The Enormous Regional Model), which was developed to deal with highly disaggregated regional data, and with the objective of analysing regional impacts of region-specific shocks. It uses data at a regional-sectorial disaggregation based on national I-O tables, together with regional data on production (for agriculture) and employment (in other sectors) for 45 regions and 38 sectors. Their findings suggest substantial negative impacts on agricultural output and income, which decreased on average by 30 per cent and 20 per cent, respectively. The most striking finding is that despite the small share of agriculture in Australian gross domestic product (GDP) (3.6 per cent), drought reduces GDP by 1.6 per cent, and worsens the balance of trade.

Diao et al. (2008), in an extension of an earlier CGE application of Diao et al. (2005), used a country-based CGE model to analyse the impacts of conjunctive groundwater (GW) and surface water (SW) management in Morocco. The objective of the study was to assess the direct and indirect effects GW regulation on agriculture and non-agricultural sectors under different scenarios such as (i) increased GW extraction costs, (ii) rural-urban transfers of SW, and (iii) reduced availability of water supplies due to drought. Although the study did not tackle climate change directly, the scenarios identified capture features of potential linkages with the latter. For instance, they found that a reduction of one standard deviation in SW irrigation supplies caused real agricultural output from all regional perimetres to fall by 11 per cent. Additionally, agricultural exports (mainly of irrigated crops) with the European Union (EU) experienced a decline of 13.6 per cent. As a result of resources' shift from irrigated to rainfed crop sectors, small increases in output occur in the latter. In addition, non-farm sectors experience a decline in real GDP and total consumption given the linkages between the irrigated crop production and the rest of the economy.

Berrittella et al. (2007) used a multi-region world CGE model, GTAP-W;[6] to analyse the effects of restricted water supply as it pertains to international trade linkages for agricultural products. Water resources usage in commodity production is captured through water intensity coefficients,[7] which describe the amount of water necessary for a sector to produce one unit of output. They analyse five scenarios to capture the effects of water scarcity due to reduced groundwater availability. Four scenarios describe 'market-based' solutions, and are contrasted with outcomes from a fifth 'non-market' scenario. Under higher constraints on water use, the world is worse off. Production and exports expand for water-intensive products in unconstrained regions, driven by shifts in trade patterns globally. Welfare gains and losses at the regional level increase with higher water-use constraints; with gains responding less proportionally and losses more than proportionally.

Berrittella et al. (2008) in an extension of a previous analysis (Berritella et al. 2007) uses the same model, GTAP-W, to analyse the impacts of trade liberalization on water use at the global level. They particularly focus their analysis on the Doha Development Agenda launched in 2001, and which sets forth a set of trade liberalization scenarios in both developed and developing countries. They find that trade liberalization induces reduction in water usage for regions with scarce supply, and increases it for water abundant regions.

Calzadilla et al. (2008) uses a CGE model to analyse the impacts of improved irrigation management under-water scarcity. They use an updated version of GTAP-W (Berrittella et al. 2007), where a new production structure is introduced, which separates rainfed and irrigated crop production. Their findings suggest that improved irrigation efficiency in water-stressed regions produces positive

6 GTAP-W is a refined version of the GTAP model that accounts for water resources, and which is based on the extension work by Burniaux and Truong (2002).

7 The water intensity coefficients are calculated based on water requirement in terms of blue water (surface and ground water) and green water (moisture stored in soil strata). The data is taken from Chapagain and Hoekstra (2004) for agricultural production and from AQUASTAT database (FAO 2013) for the water distribution services (i.e. household and industrial consumption). A major limitation with respect to the water intensity coefficients data for agriculture is that it does not differentiate between rainfed and irrigated agriculture.

effects on welfare and demand for water, whereas results are more mixed (mostly negative) for non-water scarce regions.

Thurlow et al. (2009) analyse the impacts of climate variability on economic growth and poverty reduction in Zambia. The modelling framework combines a dynamic computable general equilibrium (DGCE) model and a hydro-crop model. Projected yield impacts are simulated via the hydro-crop model for five agro-ecological zones in Zambia, and complemented with a drought index analysis to identify zonal level extreme weather events. Yield estimates from the hydro-crop modelling simulations are subsequently used to design simulation scenarios for the DGCE model to assess the climate variability impacts at the agro-ecological zones and nationally. Their findings suggest substantial negative impacts associated with climate variability. Their estimates suggest a total loss of US$4.3 billion over a ten-year period, and reach as high as US$7.1 billion under the worst rainfall scenario.

Arndt et al. (2011) develop a stochastic economy-wide framework to analyse climate change-induced economic impacts and evaluate potential adaptation policies in Ethiopia. They extend a recursive-dynamic CGE model to allow for stochastic analysis of climate change impacts. Based on statistical regression analysis, they develop a historical distribution of climate variability for Ethiopia and which serves as the baseline forward-looking scenario; i.e. historical climate variability remains unchanged in the future. Climate change impacts are accounted through parametric modifications altering the nature of the historical distribution of climate variability. Their main findings suggest that the burden of adjustment to increased climate variability in Ethiopia falls on consumers, which is expected given that productivity shocks occur in agriculture. In turn, climate-induced variability in agricultural output affects the vulnerability of poor households who spend a disproportionate share of income on food and who are disproportionately represented in agricultural labour.

Laborde (2011) analyses the impacts of climate-induced yield changes on agriculture in South Asia, and investigates the potential for trade policy options to mitigate the latter. A modified version of the MIRAGE CGE model was used, where yield estimates were first obtained via the IMPACT model for 12 climate scenarios representing alternative pathways for future agricultural productivity. The latter are constructed from the IPCC Special Report on Emission Scenarios (SRES) and general circulation models (GCM) for the climate. The SRES emission scenarios correspond to assumption about the evolution in the emission of greenhouse gases (GHG) based on the dynamics of projected economic growth, technological progress, and demographic pressures. The GCM models are numerical representations of the climate system based on the physical, chemical, and biological properties of their components (IPCC 2007). The study makes use of 3xSRES scenarios (A1B, B1, and A2) in combination with 4xGCMS (CNR, CSIRO, ECH, and MIROC) to obtain the 12 climate scenarios used in the analysis. The latter are introduced as exogenous shocks in the modified MIRAGE CGE model, where baseline results are contrasted with the results from eight different trade policy landscapes for the region. The findings suggest that pinpointing optimal trade policy is difficult in the light of uncertainty in potential climate-induced impacts on yields.

Dudu and Cakmak (2011) develop a regionalized CGE model for Turkey to analyse projected impact of climate change on agriculture and its wide economy linkages. The model is regionalized to Turkey's 12 regions at the NUTS 1 level, and corresponds to an extension and enhancement of earlier analyses (Dudu et al. 2010). Climate change impacts are modelled directly through parameterization of the production function for agricultural activities. This is achieved by explicitly modelling production as a function of yearly rainfall. Climate shocks are introduced exogenously as projected impacts on rainfall, and are based on the IPCC emission scenario SRES A2 (IPCC 2007) and the GCM ECHAM5 (Roeckner et al. 2003). Their findings suggest significant negative impacts on agricultural and food-processing sectors. Households at the lowest quintile of income distribution are worse off compared to other household groups given their propensity to spend most of their income on food products. The trade balance is significantly worsened due to increased import demand for agricultural and food products, which in turns affect the prospects of food security negatively.

Kuik et al. (2011) used the newly developed MOSAICC model (FAO 2011), in partnership with European research institutes. The model allows for country-based climate change impact analysis via its modular platform. The latter include a climate data module, which aims at statistical downscaling of climate data to be used in subsequent modules. Crop and hydrological modules are used to simulate crop growth and river basins hydrology under different climate change scenarios, using data from the previous module. An economic module, which is a country-based DCGE model,[8] was employed for the economic analysis of climate change impacts through yield variations. The authors tested the model using Morocco where data projections were used for the period 2001-30.

3 Background on Moroccan agriculture and methodological approach

3.1 Moroccan agriculture and climate

Morocco enjoys a very interesting geo-strategic location with its 3,500 kilometres of coast line, spanning the Atlantic Ocean and the Mediterranean. Equally important is its diversity in terms of landscapes and ecosystems: the mountain chains of the North, and the Northeast to the Southwest, the plateaus of the East, the plains in the West and the centre, and the desert in the South. In terms of climatology, the country enjoys a typical temperate Mediterranean climate, but with dry conditions in much of the country.[9] The country suffers from a cruel paradox in the form of advantageous precipitation patterns in the northern regions, but with very poor soil quality, and vice-versa in the southern regions (Akesbi 2006).

Upon investigating the trend in annual per cent change of agricultural value added and all others, we notice that the sector suffers from a significant volatility. This is driven by the general structure of the production, dominated by cereal crops. The latter mainly include common wheat, durum wheat, barley, and maize, which on aggregate account for 55 per cent of total value-added of crop production and occupy 65 per cent of the agricultural area. The productivity of the four main cereals experiences significant annual variations, hence the observed fluctuations characterizing the evolution of agricultural value-added (Figure 1, Appendix B). The main driver in the productivity performance of cereal production is precipitation. This is so due to the fact that most of the production is located in non-irrigated perimetrs (Figure 2, Appendix B). Export crops, mainly citrus and vegetables, represent 15 per cent of value-added and respectively occupy 0.85 and 3 per cent of the total agricultural area. Although in terms of vegetative cover of agricultural land, citrus and vegetables occupy a very small share, yet their share in agricultural value-added is substantially high given the fact that those niches are usually more labour-, chemical-, and water-intensive compared

[8] The Dynamic CGE model was developed in partnership with the Free University of Amsterdam, and is inspired by the IFPRI DCGE model (Lofgren et al. 2002; Thurlow 2004).

[9] Half of the country's area is desert, whereas the rest is split among: cultivable agricultural area (9 million Ha), forests (6 million Ha), grassland (3 million Ha), and rangeland (21 million Ha).

with cereals. Post-independence agricultural reforms that Morocco was engaged in helps explain the present situation, where upon investigating the long-term trend in the sector's performance we can identify three phases representing distinct growth patterns: Phase I (1965-1985), Phase II (1985-1991), and Phase III (1991-2012) (Figure 3, Appendix B).

The first phase was characterized by rather a weak performance of agricultural production, and even a slight decline in per capita levels. The performance recorded during this period was contingent upon the performance of policies targeting the agricultural sector adopted in the early post-independence years. The first set of policies was oriented towards a reform of the status of property rights of land ownership through the nationalization of official and private colonial lands, and their redistribution by the state (Akesbi et al. 2008). Moreover, and in parallel to the land reform efforts, a charter of agricultural investments was adopted in 1969[10] with the objective of mobilizing the hydrologic potential of the country and providing incentives for the development of irrigated perimetres. This effort has been accompanied by a set of incentives to farmers to encourage investments in new technologies (e.g. machinery, fertilizers, and seeds). Nonetheless, the state has intervened heavily and selectively to regulate markets and control prices for so-called 'strategic' commodities, which translated technically into controlling the flow of imports and exports. The economic strategy adopted by Morocco was ambitious since it involved the combination of an 'import-substitution' led growth strategy coupled with promotion of exports, and in which the agricultural sector was the main engine (Akesbi 2006). Nonetheless, the combined effect of these policies has led to an implicit taxation of the sector, especially when accompanied with the over-valued exchange rate at the time (Doukkali 2006). Hence, agricultural productivity during the period was modest. This is captured by the evolution of agricultural value-added and agricultural value-added per capita, which grew respectively by 3.7 per cent/year and 1.1 per cent/year.

During the second phase, agricultural productivity registered significant gains, with value-added rising on average by 11 per cent/year; whereas per capita levels increased by 9 per cent/year. The boost in agricultural productivity during this period came as result of favourable climatic conditions, but also due to the combined effect of the King's plan in 1985 to double the area cultivated in wheat, and the sustained liberalization effort in the agricultural sector and the exoneration of agricultural revenues from income tax. The result was an expansion of agricultural area and a reduction of small-scale farms, which came about due to increased investment and consolidation in the sector. This was depicted in the results of the General Agricultural Census in 1996, and which registered an increase in the arable agricultural area by 21 per cent. The number of small farms without land and with less than a hectare of land decreased by 85.6 and 28.3 per cent, respectively. (Doukkali 2006).

The third phase displayed a slowdown of growth in agricultural productivity at the aggregate and per capita levels. During the first half of the period, aggregate (per capita) agricultural value decreased by 32 per cent (41 per cent), from US$8.2 billion (US$332) in 1991 to US$5.6 billion (US$197) in 2000. The observed results are not surprising given the significant dependence of agricultural productivity

[10] The charter of agricultural investments, of its French name 'Code d'Investissements Agricoles (CIA)', was a set of laws passed in 1969 to primarily manage the public irrigation schemes at the time. It is presented as a contract between farmers and the state, defining rights and duties in public large scale irrigation schemes. Historically, this policy has been coined as 'Politique des Barrages', which consisted of huge investments by the state in public irrigation infrastructure (i.e. building of grand dams) with the objective of reaching the milestone of one million hectare of irrigated agricultural land by 2000 (Doukkali 2005).

on precipitation. For instance, during the agricultural campaign of 1990-91 precipitation increased by 128 per cent during the critical months of January through March, which correspond to the sowing/planting season. In turn, yield of the four main cereals registered a 41 per cent increase compared to the previous season. In the 1999-2000 campaign, we observe a decrease in precipitation by 78 per cent from the previous year. As a result, cereals yield decreased by 51 per cent. Nonetheless, the trend is reversed during the second half from 2001 onward. Aggregate (per capita) agriculture value-added reached US$11 billion (US$336) by 2012, which corresponds to an increase of 64 per cent (45 per cent) compared to 2001 levels. Annual growth for the period averaged 6 per cent/year (7 per cent/year). In terms of the policy, this period is characterized by continued effort of liberalization in the agricultural sector. Overall, the level of production compared to pre-1991 levels was clearly higher. Nonetheless, agricultural growth is still subjected to important fluctuations driven by the successive drought episodes that characterized the period, and which were particularly severe for crop production.

In conclusion, it appears that the agricultural sector in Morocco has been, and is still at the core of the state's economic strategy, given its strategic importance with respect to issues pertaining to employment, food security, poverty alleviation, etc. Despite the progress that has been achieved, there remain important challenges in the face of fully taking advantage of the potential of the agricultural sector. There is a strong consensus among policy makers that the growing hydrologic constraints in the country, owing among other things to climate change and its impacts on precipitation patterns, will be one of the major challenges in subsequent decades due to increased scarcity of water resources and demand driven by demographic pressure.

3.2 Modelling, methodology, and materials

3.2.1 Morocco's country-based CGE model

The analysis uses a regionalized general CGE model for Morocco. The model development follows IFPRI CGE modelling framework (Lofgren et al. 2002) and the Turkish regional CGE model developed by Dudu and Cakmak (2011). The model includes a number of features critical to analyses focusing on developing countries such as modules on household consumption of non-marketed (or 'subsistence') commodities, and multi input-output production structure that allows for any activity to produce multiple commodities and any commodity to be produced by multiple activities.

Production is modelled under the assumption of profit maximization subject to a production technology (Figure 1, Appendix B). The model specification allows for flexibility in terms of production technology to be used. At the top level, the technology is specified as constant elasticity of substitution (CES) function or, alternatively, a Leontief function of the quantities of value-added and aggregate intermediate input. For the purpose of our analysis, we use the default specification of a Leontief technology since we assumed that each activity at the aggregate level uses bundles of value-added and aggregated intermediate inputs to produce one or more commodities according to fixed yield coefficients. The profit-maximizing decision process assumed for each activity implies that factors are used up to the point where marginal revenue product of each factor is equal to its wage (or factor price). In the model, an economy-wide wage variable is free to vary to assure that the sum of demands from all activities equals the quantity of factor endowments, which is assumed to be fixed at the observed level.

Household consumption is modelled via a Linear Expenditure System (LES), which results from the household's utility maximization problem using a Stone-Geary utility function subject to a consumption expenditure constraint. Household consumption covers marketed commodities, purchased at market prices, and home commodities, which are valued at activity specific producer prices. Government collects taxes (fixed at ad valorem rates) and receives transfers from other institutions, which constitute its revenue. Government consumption expenditures are assumed to be fixed in real terms, transfers to domestic institutions are CPI-indexed.

At the level of commodity markets, total domestic supply comes from total aggregate output across activities, which is obtained via a CES function that accounts for the imperfect substitutability of different outputs due to, for instance, differences in quality, and distance between locations of activities. In order for market clearance to occur, an activity-specific price serves to clear the implicit market for each disaggregated commodity. In the next stage, aggregated domestic supply is allocated between exports and domestic sales via a constant elasticity of transformation (CET) function.

Domestic demand is made up of the sum of demands from households, government, investments, and intermediate inputs. The latter demands are, to the extent that a commodity is imported, for a composite commodity made up of imports and domestic output.

3.2.2 Regionalization assumptions and data

The data used in the model is based on a national social accounting matrix (SAM) for 2003 developed by Rachid Doukkali of IAV/Hassan II in Rabat, Morocco, and the modified version by Dominique Van der Mensbrugghe.[11] The initial SAM identifies 67 activities and 68 commodities (Tables 1 and 2, Appendix A). The institutional block in the data is represented by household, value-added, taxes, government, investment-savings, and rest of the world accounts (Table 3, Appendix A).

Given the regional dimension adopted in the model (Figure 4, Appendix B), it was necessary to reduce the dimension of the SAM accounts in order to facilitate the modelling enterprise and analysis, and handling of the results. Tables 4, 5, and 6 (Appendix A) summarize the new structure of the SAM accounts. Crop production is captured through 11 activity accounts each producing a corresponding commodity. Livestock, forestry, and fishery accounts remain unchanged. The food processing sectors are represented by eight activity accounts; whereas the industry and manufacturing and services accounts remain unchanged represented by four and two activity accounts, respectively.

In order to regionalize the data in SAM, official statistics on regional value-added by sector were used to compute regionalization shares. The data was obtained from a study (DSFF 2010) conducted by the Department of Studies and Financial Forecasts within the Moroccan Ministry of Economy and Finance.

3.2.3 Data sources for yield projections and selected scenarios analysis for Morocco

Yield projections were developed through a multi-step process. First, using a statistical downscaling procedure, projected change in temperatures and precipitation were obtained for Morocco at the

---

11 Dominique Van der Mensbrugghe is a senior economist at the FAO.

agro-ecological zone (AEZ) level (i.e. a downscaling from the global 250 km x 250 km grid-boxes to a finer resolution of 10 km x 10 km grid-cell compatible with the AEZ identified by the MPAM) (Figure 5, Appendix B). Second, the results of the downscaling procedure in terms of projected change in temperatures and precipitation were used to infer impacts on variables pertaining to crop growth such as evapotranspiration and water stress indicators. The study used for the determination of climate impacts yield functions calibrated using the Crop Specific Soil Water Balance (CSSWB) model (Allen et al. 1998). Estimated impacts on crop yields were provided for four time horizons, which include: current period (or baseline) covering the years 1979-2006, 2030 (2011-40), 2050 (2041-70), and 2080 (2071-99). For the purpose of the study, we used the projected yield data pertaining to the period 2050. The decision was based on the fact that most studies suggest impacts of climate change are likely to be exacerbated in the long run, but with increased uncertainty in terms of magnitude. Therefore, we chose the '2050' period as a middle-road solution since it allows us to capture the long-term impacts, but with a reduced uncertainty as to the projected impacts.

In what pertains to the scenarios identified for the analysis, we have identified eight scenarios as described in Table 7 (Appendix A). These scenarios are defined based on the climate-driven yield shocks to be introduced for selected crops, and refer to each SRES used in the analysis (A2 and B2), as well as the adaptation policies to be investigated in our analysis.

With respect to the climate-induced yield impacts, the objective is: (a) to capture the uncertainty underlying the projections in yield responses to climate change across SRES scenarios, and (b) to capture the range of uncertainty within each climate scenario, which is achieved through the percentile distribution based on 10th (low), 50th (medium), and 90th (high) percentiles of the distribution of projected yields as estimated for each SRES scenario. In this case, 'low' represents the worst case scenario in terms of impacts on yield, and 'high' represents the best case scenario, whereas 'medium' represents a median between the two.

With respect to adaptation policies to be investigated, the objective is to shed light on the relevancy of policy reforms in the PMV as an adaptive force in the face of climate change. The PMV is the new agricultural strategy adopted in Morocco in 2008, and which lays down a vision of transforming the agricultural sector by 2020 to ensure a sustainable path of productivity growth, consolidate integration with local and international markets, job creation, and mitigate poverty impacts (especially in the rural areas). The PMV includes well-defined productivity targets at the sub-national level, i.e. at the level of the administrative and economic regions identified in Table 1, achievable through a series of policy reforms centered on public-private partnerships for investment programmes divided into 'Pilier I' and 'Pilier II' programmes.[12] The PMV is mainly an investment programme. For the purpose of the analysis, we capture the adaptive potential of the PMV by converting the region-specific projected productivity gains into potential yield changes for selected crop commodities. The latter will be introduced in the model as Hicks-Neutral output-increasing technical change that compensates for the projected climate-induced yield changes. Table 8 (Appendix A) summarizes the productivity targets of the PMV strategy by crop sector.

[12] For detailed discussions of the PMV, see Ministère de l'Agriculture et de la Pêche Maritime (MAPM) and Agence pour le Développement Agricole (ADA) (2011).

4 Productivity shocks, results, and discussions

In this section, first we will discuss the projected yield estimates of the WB/Morocco/FAO study, under the different SRES scenarios (A2 and B2) and crop categories included in the analysis. Second, we will contrast projected yield impacts with the historical trend in yields for selected commodities. And last but not least, we will present a detailed discussion of our findings from the simulation results.

4.1 Historical yield trends for selected crops and projected climate-driven productivity shocks

Figure 7 represents the historical record of yields for common and durum wheat, barley, and maize from 1960 to 2006. For both wheat varieties, the trend displays a significant increase in productivity. But for barley, the historical record suggests a stagnant performance; whereas maize depicts a moderately decreasing trend. As argued in Section 3, the enhanced productivity achieved from the mid-1980s for both wheat varieties came about partly given the expansionist public policy that encouraged conversion of favourable agricultural land into wheat cultivation; while at the same time driving out barley and maize production into marginal agricultural lands (Serghini and Tyner 2005). Nonetheless, a common feature that we observe for all three crops is the high level of volatility in the yields, which is primarily explained by the high correlation between rainfall and agricultural productivity for cereal crops.

Figure 8 (Appendix B) summarizes the distribution of average yield impacts for SRES A2 and B2 as projected by 2050 for all crops at the national level. First, we notice that at the national level, projected yields depict variation across crops and climate scenarios. Based on the yield projections, we can divide the crops into three categories: negative yield impacts, mixed yield impacts, and positive yield impacts. For instance, wheat (durum and common), barley, and olives are the most negatively affected crops, where respectively, yields are projected to decline on average by -7 to -26 per cent for wheat (durum and soft), -6 to -17 per cent for barley, and -8 to -20 per cent for olives. Whereas vegetables (i.e. tomatoes, other vegetables, and industrially produced vegetables) benefit from climate change, with impacts ranging from a minimum of +2 to +7 per cent for tomatoes, +0.5 to +6 per cent for other vegetables and industrially produced vegetables. For forage crops, citrus, other fruits, and other crop, the projected impacts of climate change on yield are mixed, where they range respectively from -7 to +3 per cent for forages crops, -3 to +7 per cent for citrus, -7 to +0.6 per cent for other fruits, and -6 to +5 per cent for other crops.

Nonetheless, significant differentials in projected yield from one SRES scenario to the other exist. Additionally, there is a substantial differential in projected yield impacts within each SRES scenario when comparing with and without CO_2 fertilization cases. Figure 9 (Appendix B) summarizes the percentile distribution of projected yield impacts for all crop categories for SRES A2 and B2, with and without CO_2 fertilization effects at the national level. The latter plays a significant role in mitigating the negative impacts of climate change, but its impact is uncertain and varies widely depending on the growth conditions of crops. For instance, the projected impact on yield for tomatoes under the no CO_2 fertilization case is mixed, where it ranges from -2 to +2 per cent for SRES A2 and -3 to 3 per cent for SRES B2; whereas including CO_2 fertilization effects boosts significantly projected yield gains with the latter ranging from +8 to +16 per cent for SRES A2 and +6 to +12 per cent for SRES B2. These results are verified for other vegetables, other industrial vegetables, citrus, and other fruits crop categories. This is in line with findings from numerous impact studies in the literature that suggest that irrigated crops will experience positive impacts due to climate-induced CO_2 fertilization effects owing to higher concentrations of CO_2 in the atmosphere. Indeed, vegetable and fruit production in Morocco is mostly irrigated, which explains the observed results. As for cereals and olives, we notice that the positive impact of CO_2 fertilization effect, the latter is not large enough to induce a sign reversal in the projected yield impacts, which remains largely negative. This is explained by the fact that cereals in Morocco are grown under rainfed conditions.

Nevertheless, using national averages does not inform us on the regional distribution of projected yield impacts, which matter significantly in determining the overall impact. For instance, projected yields for durum wheat are expected to fall for all regions and all SRES scenarios. Among the hardest hit are Chaouia-Ouardigha (TR4), Doukkala-Abda (TR9), Meknes-Tafilalet (TR11), and Taza-Taounate-Al Hoceima (TR13), which respectively account for 19, 17, 9, and 16 per cent of total durum wheat production, will experience yield declines ranging from -21 to -40 per cent in TR4, -28 to +14 per cent in TR9, -12 to -22 per cent in TR11, and -11 to -31 per cent in TR13 across all scenarios without accounting for the CO_2 fertilization effects. The impacts are somewhat dampened when including the CO_2 fertilization effects, but the overall impact remains largely negative. The same patterns hold for common wheat where the overall impact is largely negative to slightly positive in the main producing regions. For tomatoes, the yield projections in most regions depict slightly positive impacts for all SRES under the no CO_2 fertilization case, and showcase substantial yield gains when we include the latter. In the main producing regions, i.e. Souss-Massa-Draa (TR2), Gharb-Cherarda (TR3), and Doukkala-Abda (TR9) regions (which respectively account for 46, 22, and 10 per cent of total production), yield impacts range from -3 to +20 per cent in TR2, -5 to +21 per cent in TR3, and -2 to +9 per cent in TR9 across all SRES scenarios, with and without CO_2 fertilization effects. The same pattern is checked for other vegetables (Figures 10a,b and 11a,b, Appendix B).

In conclusion, the results depict the wide range of variability that exists in terms of projected yield impacts at the national level, across and within SRES, but also across regions. Capturing this variability, and accounting for its economic impacts is key to understand the potential inter-regional linkages in terms of climate change, and how they translate into welfare impacts.

4.2 Findings and results

As previously mentioned, the present analysis identifies eight scenarios as defined in Table 7 (Appendix A). The model closure rules follow conventional neo-classical assumptions, where supply and demand adjust in all markets to satisfy the market clearing conditions through relative price changes.

For imports and exports, we assume that Morocco is a small country facing infinitely elastic supplies and demands at world prices. Full employment of factors is assumed, where capital and land are activity-specific; whereas labour is mobile across regions and sectors. The numeraire is assumed to be the Consumer Price Index (CPI).

At the macro level, government savings, i.e. the difference between government's revenues and expenditures, is a fixed share of GDP. In order to reach the targeted level of government savings, the tax rate is allowed to adjust uniformly across all sectors. We assume fixed foreign savings, and allow for a flexible exchange rate in order to clear the balance of the rest of the world.

As we mentioned earlier, and in conjunction to analysing the economy-wide impacts of climate change in Morocco, we aim to investigate the adaption potential of the PMV in Morocco. Table 8 (Appendix A) summarizes the key projected impacts of the PMV strategy by region and by crop. The latter are expressed in terms of per cent change of projected yield improvements achievable through the various policy reforms and investments described in the PMV. In other words, they represent assumptions on productivity enhancements which we use in our analysis as a dampening effect on the impacts of climate change. With this in mind, and given the uncertainty in the range of climate impacts as predicted for Morocco and discussed earlier, we are asking the question of whether the PMV strategy and its policy reforms agenda will be of any help as an adaptation to climate change.

Simulation results suggest that effects of climate change, under the worst case scenario, can be significant given their overall impact that act as a drag on the economic performance in all sectors, which in turn affects the performance of aggregate indicators. Indeed, the results suggest that under a severe climate shock, the overall aggregate indicators deteriorate, which indicate a contraction in the level of economic activity driven by the climate shock (Table 9, Appendix). For instance, under the worst case scenarios (i.e. no CO_2 fertilization effects and assuming no adaptation), we notice that the impact of GDP is quite substantial where the latter range from -1 to -3 per cent under SRES A2 and -0.5 to -2.3 per cent under the SRES B2. Furthermore, and upon investigating the different GDP components, we observe that consumption, investment, government spending, imports, and exports all decrease with varying degrees. Whereas a fall of imports might suggest an improvement in the balance of payments, nonetheless, we notice that the fall in exports is larger than the one observed in imports. Most of the impact on GDP can be traced back to the impact of climate change on private (household and intermediate)[13] consumption. The latter experience a fall ranging from -0.6 to -3.4 per cent across both SRES scenarios. The decline observed in investment is closely linked to one observed in private consumption, especially the one related to intermediate consumption as it relates to demand for intermediate consumption from the productive sectors in the economy, which can be thought of as a proxy to the level of economic activity. Indeed, a fall in intermediate consumption suggests a contraction in the level of economic activity of the productive sectors, which suggests less demand for investment. This contraction in the level of economic activity is clearly depicted in our results (Table 10, Appendix A), where we notice that the impact on GDP by sector is falling for all sectors. As one might expect, the agricultural sector (especially the crop production sectors) is the most hard hit due to the direct impact on yield where the impacts of sectorial GDP range from -3 to -15 per cent, followed by the food processing sectors with a decrease ranging from -1 to -6 per cent. The impact on sectorial GDP in other sectors follows a similar trend, but with varying degrees depending on the strength of their link to the agricultural sector. Historically, these results were observed in the wake of severe droughts, e.g. in the wake of the 1981 and 2000 severe droughts (Table 11, Appendix A).

Private consumption falls substantially following the increase in prices and the negative impact on household income. Indeed, household income decreases substantially, with effects more or less equally distributed across regions (Table 13, Appendix). This is driven by the decline in returns on factor payments to households due to decreased productivity captured by declining factor wages, which in turn is caused by the climate-induced contraction in factor demand from all sectors (Tables 14-17, Appendix A). Hence, the observed decline in GDP is mainly driven by the negative impacts

[13] By intermediate consumption we refer to the demand of the production sectors for intermediate inputs.

of climate change on agricultural crop production and sectors closely related to agriculture, such as the food processing sector. For instance, aggregate agricultural crop production declines by -15 per cent for the worst case scenario under SRES, and assuming no adaptation. Aggregated output from food processing sectors, due to their direct linkages with the agricultural sector follows a similar trend, albeit with a lesser magnitude in terms of impacts. The effects are somewhat lessened under the SRES B2, but remains mostly negative.

Overall, under both SRES scenarios (A2 and B2) and assuming no-adaptation, impacts on agriculture range from a serious fall in production under the 'low productivity' scenario assuming no CO_2 fertilization effects to a moderate increase driven by the positive dampening effect of CO_2 fertilization effects[14] on crop yields under the 'high productivity' scenario (Table 18, Appendix A). Factor employment drastically increases to compensate the loss in production due to declining yields. Agricultural trade deficit deteriorates tremendously under the worst case scenarios. For instance, assuming no-adaptation under the A2_noCO_2_low, imports increase by more than 30 per cent while exports decrease by 11 per cent. The impacts are lessened under the 'medium' and 'high' productivity scenarios, and the impacts get reversed under the 'high productivity' scenario if we include CO_2 fertilization effects on yield.

Food processing is the second most-affected sector from the climate change. Most indicators for the sector closely follow the observed trend in agricultural production sector (Table 19, Appendix A). Factors of employment respond to the change in wages in all scenarios. The trade figures move in the same direction compared to the agricultural sector. The other sectors follow the food production sector with less significant changes in production and employment.

However, and given the uncertainty underlying the climate projections and their impacts on yields as discussed earlier, it seems that Morocco will have time to adjust to adverse effects of climate change for a limited period of time if policies are adopted in a timely manner. This is depicted by our results (Table 9, Appendix A), where we observe a substantial positive impact when we include the PMV adaptation targets and also the CO_2 fertilization effects. Indeed, including the PMV targets boosts agricultural production significantly, and especially under the scenario including the CO_2 fertilization effects (Table 18, Appendix A). The increase reaches up to 20 per cent under the best case scenario of 'A2_wCO_2_High', which is mainly due to increased yield. Wages faced by agricultural sector increased since marginal productivity of factors increase when yields increase. Consequently factor employment decreases. However, note that the decline in factor employment is quite low compared to the improvement in yield. Agricultural trade deficit significantly improves as a result of increasing exports and declining imports. These conclusions rest on the assumption that the capital investments programmed in the PMV will, in fact, achieve the targeted productivity increases. There are reasons to believe that achieving these targets will be a real challenge.

5 Conclusion

The agricultural sector in Morocco consists of a heterogeneous distribution of production activity across regions. This diversity in the regional structure of agriculture brings about complicated

[14] The latter vary quite significantly from one SRES scenario to other and across crops. From our computations using the data from the WB/Morocco/FAO study, we find that the latter fall within the range of +2 per cent (olives) to +15 per cent (tomatoes).

linkages in terms of projected impacts of climate change across regions, which in turn trickles down to affect the rest of the economy.

In this paper, we attempt to shed light on inter-regional linkages under different climate-driven agricultural productivity shocks using a regional adaptation of a CGE model. In Morocco, climate change intervenes by substantially changing the regional production patterns and hence, introduces changes in prices of commodities. As showcased in the results, agriculture, and to a certain degree, food processing sectors production levels are substantially affected by climate change. Depending on the strength of the linkages that exist between the primary sector and the rest of the economy, the former tend to act as a drag on the rest of the sectors under the worst case scenarios where substantial climate-induced yield shocks (mostly negative) tend to trickle down and affect productivity in other sectors through many channels, such as increased prices for primary inputs and reduced demand for private and intermediate consumption.

Like any research, there are areas for improvement in the future. Currently inter-regional linkages are modelled simplistically through redistribution of excess supply regions to excess demand regions based on their shares. Alternative approaches could be explored. Additionally, the projected impacts of the PMV investments strategy are captured using the simplistic assumption of compensating climate-induced yield losses by the projected yield improvements entailed under the PMV. A better strategy would be to directly model the provisional impacts of the PMV investments into our modelling framework, which is beyond the aim of this paper.

Finally, there is need to update the data used in the analysis. The current model assumes all regional households have the same preferences, but differ only based on their level of expenditure from one region to the other. Access to better household surveys could provide us with better understanding the dynamics of consumption patterns and a better evaluation of welfare impacts.

References

Agence de Développement Agricole (ADA) (2014). 'Plan Maroc Vert (PMV)'. Rabat: ADA. Available at: http://www.ada.gov.ma/PlanMarocVert.php (last accessed 24 April 2014).

Akesbi N. (2006). 'Evolution et Perspectives de L'agriculture Marocaine'. Cinquante ans de Développement Humain au Maroc (Maroc). 50 Ans de Développement Humain au Maroc, Perspectives 2025: Rapports Thématiques. Maroc: Cinquante ans de Développement Humain au Maroc. Rabat: Cinquantenaire de Indépendance du Royaume du Maroc.

Akesbi, N., D. Benatya, and N. El Aoufi (2008). *L'agriculture Marocaine a l'Épreuve de la Libéralisation*. Rabat: Economie Critique.

Allen, R.G., L.S. Pereira, D. Raes, and M. Smith (1998). 'Crop Evapotranspiration-Guidelines for Computing Crop Water Requirements'. FAO Irrigation and Drainage Paper 56. Rome: FAO. Available at: http://www.fao.org/docrep/X0490E/x0490e00.HTM (accessed 17 April 2014).

Arndt, C., S. Robinson, and D. Willenbockel (2011). 'Ethiopia's Growth Prospects in a Changing Climate: a Stochastic General Equilibrium Approach'. *Global Environmental Change*, 21(2011): 701-10.

Berrittella, M., A.Y. Hoekstra, K. Rehdanz, R. Roson, and R.S.J. Tol (2007). 'The Economic Impact of Restricted Water Supply: A Computable General Equilibrium Analysis'. *Water Research*, 41(8): 1799-803.

Berrittella, M., K. Rehdanz, R.S.J. Tol, J. Zhang (2008). 'The Impact of Trade Liberalization on Water Use: A Computable General Equilibrium Analysis'. *Journal of Economic Integration*, 23(3): 631-55.

Burniaux, J.-M., and T.P. Truong (2002). 'GTAP-E: An Energy-Environmental Version of the GTAP Model'. GTAP Technical Papers, Paper 18. West Lafayette: Purdue University. Available at: http://docs.lib.purdue.edu/gtaptp/18 (accessed 16 April 2014).

Calzadilla, A., K. Rehdanz, and R.S.J. Tol (2008). 'Water Scarcity and the Impact of Improved Irrigation Management: a CGE Analysis'. Working Paper 1436. Kiel: Kiel Institute for the World Economy.

Chapagain, A.K., and A.Y. Hoekstra (2004). 'Water Footprints of Nations'. Institute for Water Education, Value of Water Research Report Series 16. Delft: UNESCO-IHE.

Cline, W.R. (2007). 'Global Warming and Agriculture: Impacts Estimates by Country'. Washington, DC: Center for Global Development/Peterson Institute for International Economics.

Department of Studies and Financial Forecasts (DSFF) (2010). 'Regions in Morocco: Sector-based Contribution to National Wealth Creation'. Rabat: Ministry of Economy and Finance (MEF).

Diao, X., T. Roe, and R. Doukkali (2005). 'Economy-Wide Gains from Decentralized Water Allocation in a Spatially Heterogeneous Agricultural Economy'. *Environment and Development Economics*, 10: 249-69.

Diao, X., A. Dinar, T. Roe, and Y. Tsur (2008). 'A General Equilibrium Analysis of Conjunctive Ground and Surface Water Use with an Application to Morocco'. *Agricultural Economics*, 38(2): 117-35.

Doukkali R. (2005). 'Water Institutional Reforms in Morocco'. *Water Policy*, 7(2005): 71-88.

Doukkali, R. (2006). 'Evolution des Performances du Secteur Agricole: Résultats d'une Expérience'. Working Paper. Rabat: Centre National de Documentation du Maroc: BdD Développement Economique et Social.

Dudu, H., E.H. Cakmak, and D.S. Saraçoğlu (2010). 'Climate Change and Agriculture in Turkey: A CGE Modelling Approach'. *İktisat İşletme ve Finans Dergisi*, 25(286): 9-33.

Dudu, H., and E.H. Cakmak (2011). 'Regional Impact of the Climate Change: a CGE Analysis for Turkey'. Working Paper 644. Giza: Economic Research Forum.

Fischer, G., M. Shah, F.N. Tubiello, and H. van Velhuizin (2005). 'Socio-Economic and Climate Change Impacts an Agriculture: an Integrated Assessment, 1990-2080'. *Philosophical Transactions of the Royal Society*, 360(1463): 2067-83.

Food and Agriculture Organization (FAO) (2009). 'The State of Agricultural Commodity Markets: High Food Prices and the Food Crisis—Experiences and Lessons Learned'. Rome: FAO.

FAO (2010). 'Climate-Smart Agriculture: Policies, Practices and Financing for Food Security, Adaptation and Mitigation'. Rome: FAO.

FAO (2011). 'Modelling System for Agricultural Impacts of Climate Change (MOSAICC)'. Available at: http://www.fao.org/climatechange/mosaicc/en/ (last accessed 16 April 2014).

FAO, Food and Agriculture Organization (2013). 'AQUASTAT Database'. Rome: FAO. Available at: http://www.fao.org/nr/water/aquastat/main/index.stm (last accessed 22 April 2014).

Gommes, R., T. El Hairech, D. Rosillon, R. Balaghi, and H. Kanamaru (2009). 'Impact of Climate Change on Agricultural Yields in Morocco'. Rome: FAO. Available at: ftp://ext-ftp.fao.org/SD/Reserved/Agromet/WB_FAO_morocco_CC_yield_impact/report/ (last accessed 22 April 2014).

Horridge, M., J. Madden, and G. Wittwer (2005). 'The Impact of the 2002-2003 Drought on Australia'. *Journal of Policy Modeling*, 27(3): 285-308.

Intergovernmental Panel on Climate Change (IPCC) (2007). 'Impacts, Adaptation and Vulnerability'. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva: IPCC.

Kuik, O., F. Reynes, F. Delobel, and M. Bernardi (2011). 'FAO-MOSAICC: The FAO Modelling System for Agricultural Impacts of Climate Change to Support Decision-Making in Adaptation'. Paper presented at the proceedings of the 14th GTAP Conference in Venice, Italy.

Laborde, D. (2011). 'Climate Change and Agriculture in South Asia: Studying Optimal Trade Policy Options'. Paper presented at the proceedings of the 14th GTAP Conference in Venice, Italy.

Lofgren, H., R.L. Harris, and S. Robinson (2002). 'A Standard Computable General Equilibrium (CGE) Model in GAMS'. Washington, DC: IFPRI.

Ministère de l'Agriculture et de la Pêche Maritime (MAPM), and Agence pour le Développement Agricole (ADA) (2011). 'Projet d'Intégration du Changement Climatique dans la Mise en œuvre du Plan Maroc Vert (PICCPMV): Etude Cadre de l'Impact Environnemental et Social'. Ministère de l'Agriculture et de la Pêche Maritime (MAPM) and Fonds de Développement Agricole (FDA) (2011). Les Aides Financiers de l'Etat pour l'encouragement des investissements agricoles. Rabat: Agence pour le Développement Agricole.

Roeckner, E., G. Bäuml, L. Bonaventura, R. Brokopf, M. Esch, M. Giorgetta, S. Hagemann, I. Kirchner, L. Kornblueh, E. Manzini, A. Rhodin, U. Schlese, U. Schultzweida, and A. Tompkins (2003). 'The Atmospheric General Circulation Model ECHAM5: Model Description'. Report 349. Hamburg: Max-Plack Institute for Meteorology.

Serghini, H., and W. Tyner (2005). 'Des Elements de Reformes du Secteur Agricole'. Unpublished paper from the Ministry of Agriculture and Fisheries. Rabat: Ministry of Agriculture and Fisheries.

Thurlow, J. (2004). 'A Dynamic Computable General Equilibrium (CGE) Model for South Africa: Extending the Static IFPRI Model'. Trade and Industrial Policy Strategies, Working Paper 1. Pretoria: International Food Policy Research Institute.

Thurlow, J., T. Zhu, and X. Diao (2009). 'The Impact of Climate Variability and Change on Economic Growth and Poverty in Zambia'. IFPRI Discussion Paper 00890. Washington, DC: International Food Policy Research Institute.

World Bank (2010). 'World Development Report'. Washington, DC: World Bank.

World Bank (2014). 'World Development Indicators for Morocco'. Washington, DC: World Bank. Available at: http://data.worldbank.org/country/morocco (last accessed 28 April 2014).

APPENDIX A: Tables

Table 1: Nomenclature of activity accounts in the Morocco's social accounting matrix

Sectors/Activities	Description	Sectors/Activities	Description
Agriculture, crops (x26)		xmeat-a	Other meat production
hdwht-a	Hard wheat	Pasture (x2)	
sfwht-a	Soft wheat	fl-a	Fallow land
barly-a	Barley	ps-a	Pasture land
xgrns-a	Other grains	Byproducts (x2)	
gnleg-a	Grain legumes	sp-a	Agricultural byproducts
sgrbt-a	Sugar beets	spfdp-a	Byproducts of agro-food industries
sgrcn-a	Sugar cane	Forestry (x1)	
xcshc-a	Other industrial crops incl oil seeds	forst-a	Forestry
tomat-a	Tomatoes	Fishery (x1)	
potat-a	Potatoes	fshry-a	Fishery
onion-a	Onions	Food processing (x10)	
melon-a	Melons	dairy-a	Dairy
wtmln-a	Watermelons	sgrrw-a	Raw sugar
xvegt-a	Other vegetables	sgrrf-a	Refined sugar
xvgin-a	Other industrial vegetables	milhw-a	Hard wheat mill
alfaf-a	Alfafa	milsw-a	Soft wheat mill
forag-a	Forage crops	oilrw-a	Raw oil
olive-a	Olives	oilrf-a	Refined oil
agrms-a	Clementines and small citrus	olvwh-a	Whole olives
xagrm-a	Other citrus	olvol-a	Olive oil
grape-a	Grapes	xfdpr-a	Other food processing
almnd-a	Almonds	Industry and manufacturing (x4)	
apple-a	Apples	chmcl-a	Chemical industries
dates-a	Dates	refol-a	Refined petroleum
xfrut-a	Other fruit	wtrel-a	Water and electricity utilities
xcrop-a	Other crops nes	xinds-a	Other industries
Livestocks (x4)		Services (x2)	
bovin-a	Bovine meat	srvpr-a	Private services
ovine-a	Sheep and other red meats	srvpb-a	Public services
avine-a	Poultry		

Source: Authors' adaptation based on data from Doukkali's SAM (2003).

Table 2: Nomenclature of commodity accounts in the Morocco's social accounting matrix

Commodities	Description	Commodities	Description
Agriculture, crops (x26)		eggrw-c	Eggs
hdwht-c	Hard wheat	xmeat-c	Other animal products
sfwht-c	Soft wheat	Pasture (x2)	
barly-c	Barley	fl-c	Fallow land
xgrns-c	Other grains	ps-c	Pasture land
gnleg-c	Grain legumes	Byproducts (x2)	
sgrbt-c	Sugar beets	sp-c	Agricultural byproducts
sgrcn-c	Sugar cane	spfdp-c	Byproducts of agro-food industries
xcshc-c	Other industrial crops incl oil seeds	Forestry (x1)	
tomat-c	Tomatoes	forst-c	Forestry
potat-c	Potatoes	Fishery (x1)	
onion-c	Onions	fshry-c	Fishery
melon-c	Melons	Food processing (x10)	
wtmln-c	Watermelons	dairy-c	Dairy
xvegt-c	Other vegetables	sgrrw-c	Raw sugar
xvgin-c	Other industrial vegetables	sgrrf-c	Refined sugar
alfa-c	Alfafa	milhw-c	Hard wheat mill
forag-c	Forage crops	milsw-c	Soft wheat mill
olive-c	Olives	oilrw-c	Raw oil
agrms-c	Clementines and small citrus	oilrf-c	Refined oil
xagrm-c	Other citrus	olvwh-c	Whole olives
grape-c	Grapes	olvol-c	Olive oil
almnd-c	Almonds	xfdpr-c	Other food processing
apple-c	Apples	Industry and manufacturing (x4)	
dates-c	Dates	chmcl-c	Chemical industries
xfrut-c	Other fruit	refol-c	Refined petroleum
xcrop-c	Other crops nes	wtrel-c	Water and electricity utilities
Livestocks (x5)		xinds-c	Other industries
meatr-c	Red meats	Services (x2)	
meatw-c	White meats	srvpr-c	Private services
mlkrw-c	Raw milk	srvpb-c	Public services

Source: Authors' adaptation based on data from Doukkali's SAM (2003).

Table 3: Nomenclature of institutional accounts in the Morocco's social accounting matrix

Institution	Description	Institution	Description
vaadd	Value added	rhdc1	Rural households first decile
txsub	Taxes and subsidies	rhdc2	Rural households second decile
govnt	Government	rhdc3	Rural households third decile
uhdc1	Urban households first decile	rhdc4	Rural households fourth decile
uhdc2	Urban households second decile	rhdc5	Rural households fifth decile
uhdc3	Urban households third decile	invst	Investment savings account
uhdc4	Urban households fourth decile	rowld	Rest of the world
uhdc5	Urban households fifth decile		

Source: Authors' adaptation based on data from Doukkali's SAM (2003).

Table 4: Updated nomenclature of activity accounts for the 2003 Morocco's social accounting matrix

Sectors/Activities	Description	Sectors/Activities	Description
Agriculture, crops (x11)		Fishery (x1)	
hdwht-a	Hard wheat	fshry-a	Fishery
sfwht-a	Soft wheat	Food processing (x8)	
barly-a	Barley	dairy-a	Dairy
tomat-a	Tomatoes	sugar-a	Sugar processing
xvegts-a	Other vegetables	milhw-a	Hard wheat mill
xvgin-a	Other industrial vegetables	milsw-a	Soft wheat mill
forags-a	Forage crops	oilpr-a	Processed oil
olive-a	Olives	olvwh-a	Whole olives
agrms-a	Citrus	olvol-a	Olive oil
xfruts-a	Other fruit	xfdpr-a	Other food processing
xcrops-a	Other crops nes	Industry and manufacturing (x4)	
Livestocks (x4)		chmcl-a	Chemical industries
bovin-a	Cattle etc.	refol-a	Refined petroleum
ovine-a	Sheep	wtrel-a	Water and electricity utilities
avine-a	Poultry	xinds-a	Other industries
xmeat-a	Other animal products	Services (x2)	
Forestry (x1)		srvpr-a	Private services
forst-a	Forestry	srvpb-a	Public services

Source: Authors' adaptation based on data from Doukkali's SAM (2003).

Table 5: Updated nomenclature of commodity accounts for the 2003 Morocco's social accounting matrix

Commodity account	Description	Commodity account	Description
Agriculture, crops (x11)		Fishery (x1)	
hdwht-c	Hard wheat	fshry-c	Fishery
sfwht-c	Soft wheat	Food processing (x8)	
barly-c	Barley	dairy-c	Dairy
tomat-c	Tomatoes	sugar-c	Sugar processing
xvegts-c	Other vegetables	milhw-c	Hard wheat mill
xvgin-c	Other industrial vegetables	milsw-c	Soft wheat mill
forags-c	Forage crops	oilpr-c	Processed oil
olive-c	Olives	olvwh-c	Whole olives
agrms-c	Citrus	olvol-c	Olive oil
xfruts-c	Other fruit	xfdpr-c	Other food processing
xcrops-c	Other crops nes	Industry and manufacturing (x4)	
Livestocks (x4)		chmcl-c	Chemical industries
meatrbov-c	Cattle etc	refol-c	Refined petroleum
meatrov-c	Sheep	wtrel-c	Water and electricity utilities
meatw-c	Poultry	xinds-c	Other industries
xmeat-c	Other animal products	Services (x2)	
Forestry (x1)		srvpr-c	Private services
forst-c	Forestry	srvpb-c	Public services

Source: Authors' adaptation based on data from Doukkali's SAM (2003).

Table 6: Updated nomenclature of institutional accounts for the 2003 Morocco's social accounting matrix

Institution	Description	Institution	Description
Value-added accounts		comtax	Commodity tax
flab	Labour	imptax	Tariff
fcap	Capital	instax	Institutional tax
flandfl	Fallow land	factax	Factor Taxes
flandps	Pasture land	Government account	
flandir	Irriagted land	gov	Government
flandrf	Rainfed land	Savings-Investment	
Households account		s-i	saving-investment
uh	Urban household	Rest of the world	
rh	Rural household	row	rest of the world
Tax accounts			
actax	Activity tax		

Source: Authors' adaptation based on data from Doukkali's SAM (2003).

Table 7: 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 based on the study of WB/Morocco/FAO (Gommes et al. 2009).

Table 8: Projected yield impacts of the Plan Maroc Vert 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' calculations based on ADA (2014).

Table 9: Effects on macro accounts and gross domestic product (GDP)—without and with adaptation (base values in million Dhs)

	BASE	Climate change, no adaptation (% change from base)											
		A2_noCO2			B2_noCO2			A2_wCO2			B2_wCO2		
		Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Absorption - A = C + I + G	492,093	-2.98%	-1.62%	-0.86%	-2.27%	-1.18%	-0.49%	-1.32%	-0.21%	0.55%	-1.35%	-0.24%	0.39%
Consumption - C	272,986	-3.37%	-1.84%	-0.97%	-2.61%	-1.36%	-0.56%	-1.50%	-0.18%	0.71%	-1.55%	-0.24%	0.51%
Investment - I	133,622	-2.88%	-1.54%	-0.84%	-2.09%	-1.10%	-0.48%	-1.29%	-0.31%	0.35%	-1.27%	-0.29%	0.26%
Government - G	85,485	-1.91%	-1.01%	-0.53%	-1.45%	-0.74%	-0.30%	-0.83%	-0.13%	0.35%	-0.85%	-0.15%	0.25%
Exports - X	139,736	-0.85%	-0.44%	-0.22%	-0.71%	-0.27%	0.00%	-0.03%	0.45%	0.69%	-0.14%	0.32%	0.55%
Imports - M	-153,254	-0.78%	-0.40%	-0.20%	-0.65%	-0.25%	0.00%	-0.02%	0.41%	0.63%	-0.13%	0.30%	0.50%
Gross Domestic Product (GDP)	478,574	-3.07%	-1.66%	-0.88%	-2.33%	-1.21%	-0.51%	-1.36%	-0.21%	0.57%	-1.39%	-0.24%	0.40%
		Climate change, with adaptation-PMV (% change from base)											
	BASE	A2_noCO2			B2_noCO2			A2_wCO2			B2_wCO2		
		Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Absorption - A = C + I + G	492,093	-0.26%	1.00%	1.69%	0.39%	1.39%	2.02%	1.30%	2.31%	3.00%	1.26%	2.27%	2.83%
Consumption - C	272,986	0.05%	1.47%	2.28%	0.75%	1.91%	2.64%	1.82%	3.01%	3.83%	1.76%	2.95%	3.62%
Investment - I	133,622	-0.90%	0.34%	0.98%	-0.17%	0.74%	1.31%	0.63%	1.51%	2.12%	0.62%	1.51%	2.00%
Government - G	85,485	-0.28%	0.52%	0.95%	0.14%	0.76%	1.14%	0.71%	1.30%	1.72%	0.68%	1.27%	1.62%
Exports - X	139,736	1.47%	1.89%	2.14%	1.56%	2.07%	2.36%	2.32%	2.84%	3.12%	2.18%	2.70%	2.94%
Imports - M	-153,254	1.34%	1.73%	1.95%	1.43%	1.89%	2.15%	2.12%	2.59%	2.85%	1.99%	2.46%	2.69%
Gross Domestic Product (GDP)	478,574	-0.27%	1.03%	1.74%	0.40%	1.43%	2.08%	1.34%	2.37%	3.08%	1.30%	2.33%	2.91%

Source: Simulations results.

Table 10: Effects gross domestic product (GDP) disaggregated by sectors—without and with adaptation (base values in million Dhs)

		Climate change, no adaptation (% change from base)											
	BASE	A2_noCO2			B2_noCO2			A2_wCO2			B2_wCO2		
		Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Agriculture (crop production)	52,047	-14.50%	-8.08%	-4.12%	-11.46%	-6.12%	-2.56%	-6.73%	-0.88%	3.40%	-7.15%	-1.25%	2.20%
Livestock	11,260	-4.32%	-2.51%	-1.38%	-3.53%	-1.84%	-0.89%	-2.33%	-0.63%	0.55%	-2.30%	-0.56%	0.40%
Forestry	1,072	1.14%	0.60%	0.30%	0.97%	0.50%	0.22%	0.61%	0.00%	-0.36%	0.69%	0.07%	-0.24%
Fisheries	5,065	-2.47%	-1.51%	-0.90%	-1.95%	-1.09%	-0.57%	-1.42%	-0.67%	-0.08%	-1.30%	-0.53%	-0.07%
Dairy	618	-1.96%	-1.17%	-0.55%	-1.91%	-0.82%	-0.30%	-1.04%	-0.08%	0.52%	-1.10%	-0.07%	0.39%
Food processing	22,133	-5.89%	-3.34%	-1.87%	-4.53%	-2.51%	-1.24%	-3.17%	-1.01%	0.52%	-3.09%	-0.92%	0.35%
Industry and manufacture	99,567	-0.60%	-0.31%	-0.21%	-0.38%	-0.19%	-0.09%	-0.18%	-0.04%	0.02%	-0.17%	-0.02%	0.05%
Services	232,890	-1.56%	-0.86%	-0.47%	-1.18%	-0.62%	-0.26%	-0.67%	-0.13%	0.24%	-0.66%	-0.14%	0.18%
		Climate change, with adaptation-PMV (% change from base)											
	BASE	A2_noCO2			B2_noCO2			A2_wCO2			B2_wCO2		
		Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Agriculture (crop production)	52,047	2.35%	8.48%	12.21%	5.17%	10.30%	13.65%	9.95%	15.51%	19.59%	9.44%	15.05%	18.29%
Livestock	11,260	-2.72%	-0.99%	0.05%	-1.94%	-0.36%	0.52%	-0.83%	0.76%	1.83%	-0.77%	0.83%	1.71%
Forestry	1,072	-0.07%	-0.56%	-0.83%	-0.21%	-0.64%	-0.90%	-0.56%	-1.15%	-1.50%	-0.47%	-1.06%	-1.36%
Fisheries	5,065	-1.44%	-0.55%	0.01%	-0.93%	-0.15%	0.31%	-0.46%	0.19%	0.70%	-0.33%	0.33%	0.73%
Dairy	618	-1.24%	-0.53%	0.05%	-1.23%	-0.20%	0.27%	-0.38%	0.50%	1.04%	-0.44%	0.50%	0.90%
Food processing	22,133	-2.05%	0.29%	1.63%	-0.77%	1.05%	2.19%	0.47%	2.36%	3.73%	0.56%	2.45%	3.58%
Industry and manufacture	99,567	-0.04%	0.22%	0.30%	0.17%	0.32%	0.41%	0.35%	0.45%	0.49%	0.36%	0.47%	0.51%
Services	232,890	-0.21%	0.42%	0.78%	0.14%	0.64%	0.97%	0.61%	1.08%	1.40%	0.63%	1.07%	1.35%

Source: Simulations results.

Table 11: Macroeconomic impacts of historical droughts in Morocco

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 based on World Bank (2014).

Table 12: Per cent change in aggregate domestic output by sector—without and with adaptation (base values in million Dhs)

		Climate change, no adaptation (% change from base)											
	BASE	A2_noCO2			B2_noCO2			A2_wCO2			B2_wCO2		
		Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Agriculture (crop production)	75,813	-4.26%	-2.07%	-0.74%	-3.57%	-1.64%	-0.45%	-1.59%	0.68%	2.18%	-2.08%	0.23%	1.38%
Livestock	34,380	-1.74%	-0.47%	0.06%	-1.13%	-0.28%	0.25%	0.04%	0.79%	1.30%	-0.24%	0.54%	0.94%
Forestry &Fishery	10,162	-4.54%	-2.58%	-1.48%	-3.47%	-1.87%	-0.88%	-2.25%	-0.73%	0.34%	-2.16%	-0.63%	0.25%
Dairy	5,856	-3.78%	-2.08%	-1.10%	-3.02%	-1.50%	-0.65%	-1.80%	-0.37%	0.58%	-1.82%	-0.35%	0.42%
Food processing	166,078	-4.74%	-2.54%	-1.38%	-3.56%	-1.85%	-0.79%	-2.16%	-0.44%	0.72%	-2.16%	-0.44%	0.55%
Industry and manufacture	544,386	-3.06%	-1.67%	-0.99%	-2.25%	-1.18%	-0.55%	-1.37%	-0.39%	0.22%	-1.32%	-0.34%	0.19%
Services	592,030	-3.83%	-2.09%	-1.14%	-2.91%	-1.52%	-0.66%	-1.70%	-0.30%	0.62%	-1.71%	-0.32%	0.45%
		Climate change, no adaptation (% change from base)											
	BASE	A2_noCO2			B2_noCO2			A2_wCO2			B2_wCO2		
		Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Agriculture (crop production)	75,813	3.73%	5.62%	6.74%	4.18%	5.89%	6.91%	6.17%	8.21%	9.58%	5.57%	7.65%	8.68%
Livestock	34,380	0.67%	1.81%	2.28%	1.23%	1.96%	2.42%	2.31%	2.88%	3.31%	2.03%	2.64%	2.96%
Forestry &Fishery	10,162	-1.93%	-0.15%	0.83%	-0.91%	0.49%	1.35%	0.17%	1.44%	2.34%	0.29%	1.55%	2.29%
Dairy	5,856	-1.20%	0.32%	1.19%	-0.50%	0.83%	1.57%	0.62%	1.82%	2.62%	0.60%	1.82%	2.47%
Food processing	166,078	-1.85%	0.16%	1.21%	-0.74%	0.78%	1.72%	0.52%	1.99%	2.99%	0.56%	2.00%	2.85%
Industry and manufacture	544,386	-0.82%	0.39%	0.96%	-0.07%	0.80%	1.33%	0.69%	1.45%	1.92%	0.76%	1.50%	1.90%
Services	592,030	-0.63%	0.94%	1.78%	0.22%	1.44%	2.20%	1.33%	2.50%	3.29%	1.33%	2.48%	3.14%

Source: Simulations results.

Table 13: Effects on household income at the regional and national level–without and with adaptation (base values in million Dhs)

	BASE	Climate change, no adaptation (% change from base)											
		A2_noCO2			B2_noCO2			A2_wCO2			B2_wCO2		
		Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
TR1	10,365	-3.77%	-2.10%	-1.21%	-2.85%	-1.53%	-0.73%	-1.86%	-0.58%	0.31%	-1.81%	-0.52%	0.21%
TR2	33,508	-3.30%	-1.66%	-0.64%	-2.51%	-1.19%	-0.25%	-0.98%	0.73%	1.82%	-1.26%	0.45%	1.30%
TR3	23,649	-1.64%	-0.77%	-0.18%	-1.96%	-0.46%	0.30%	0.00%	1.85%	2.47%	-0.09%	1.27%	1.89%
TR4	24,596	-4.98%	-2.94%	-1.00%	-3.76%	-2.22%	-0.95%	-3.15%	-1.66%	0.13%	-2.75%	-1.35%	-0.22%
TR5	31,369	-3.19%	-1.84%	-1.08%	-2.38%	-1.38%	-0.73%	-1.55%	-0.49%	0.25%	-1.60%	-0.47%	0.23%
TR6	29,339	-3.24%	-1.76%	-1.08%	-2.71%	-1.44%	-0.67%	-1.62%	-0.24%	0.55%	-1.69%	-0.43%	0.40%
TR7	107,311	-3.81%	-2.08%	-1.17%	-2.85%	-1.52%	-0.70%	-1.81%	-0.52%	0.36%	-1.77%	-0.47%	0.27%
TR8	40,695	-4.01%	-2.31%	-1.44%	-3.07%	-1.68%	-0.91%	-2.15%	-0.83%	0.04%	-2.05%	-0.69%	0.02%
TR9	24,742	-4.29%	-1.63%	-0.61%	-2.57%	-1.31%	-0.39%	-0.91%	0.18%	1.14%	-1.45%	-0.14%	0.82%
TR10	14,973	-2.09%	-0.60%	-0.09%	-1.26%	-0.28%	0.28%	0.39%	0.99%	1.41%	-0.26%	0.73%	1.03%
TR11	27,666	-2.99%	-1.86%	-1.18%	-2.47%	-1.41%	-0.83%	-2.12%	-0.84%	-0.03%	-2.01%	-0.67%	-0.04%
TR12	22,580	-4.23%	-2.49%	-1.54%	-3.32%	-1.80%	-0.96%	-2.35%	-0.95%	0.00%	-2.27%	-0.76%	-0.02%
TR13	14,867	-4.92%	-2.86%	-1.95%	-3.82%	-2.00%	-1.24%	-2.95%	-1.38%	-0.53%	-2.75%	-1.00%	-0.36%
TR14	34,661	-3.48%	-1.69%	-0.92%	-2.57%	-1.20%	-0.45%	-1.28%	0.08%	0.84%	-1.29%	-0.02%	0.65%
National_Urban	344,485	-3.58%	-1.92%	-1.03%	-2.73%	-1.41%	-0.61%	-1.63%	-0.30%	0.59%	-1.66%	-0.32%	0.42%
National_Rural	95,838	-3.69%	-1.98%	-1.06%	-2.81%	-1.46%	-0.63%	-1.68%	-0.31%	0.61%	-1.71%	-0.33%	0.43%
National	440,323	-3.60%	-1.94%	-1.04%	-2.75%	-1.42%	-0.62%	-1.64%	-0.30%	0.59%	-1.67%	-0.32%	0.42%
		Climate change, with adaptation-PMV (% change from base)											
	BASE	A2_noCO2			B2_noCO2			A2_wCO2			B2_wCO2		
		Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
TR1	10,365	-1.22%	0.28%	1.06%	-0.35%	0.78%	1.48%	0.53%	1.60%	2.35%	0.60%	1.65%	2.26%
TR2	33,508	0.26%	1.78%	2.74%	0.98%	2.20%	3.09%	2.46%	4.01%	5.06%	2.15%	3.73%	4.53%
TR3	23,649	3.18%	3.87%	4.35%	2.62%	4.10%	4.77%	4.62%	6.41%	6.93%	4.51%	5.76%	6.30%
TR4	24,596	-1.47%	0.29%	2.10%	-0.41%	0.90%	2.03%	0.13%	1.29%	2.91%	0.45%	1.56%	2.56%
TR5	31,369	-0.76%	0.49%	1.16%	0.03%	0.88%	1.45%	0.75%	1.68%	2.32%	0.74%	1.68%	2.27%
TR6	29,339	0.06%	1.42%	2.04%	0.56%	1.72%	2.42%	1.58%	2.82%	3.55%	1.53%	2.65%	3.41%
TR7	107,311	-1.25%	0.29%	1.08%	-0.35%	0.78%	1.49%	0.57%	1.63%	2.36%	0.63%	1.67%	2.28%
TR8	40,695	-1.11%	0.37%	1.10%	-0.24%	0.91%	1.56%	0.56%	1.62%	2.32%	0.66%	1.74%	2.31%
TR9	24,742	-0.54%	2.01%	2.93%	1.17%	2.25%	3.05%	2.71%	3.58%	4.41%	2.20%	3.26%	4.06%
TR10	14,973	0.66%	2.16%	2.63%	1.46%	2.45%	2.98%	3.17%	3.74%	4.13%	2.44%	3.45%	3.72%
TR11	27,666	-0.10%	0.64%	1.11%	0.23%	0.95%	1.37%	0.37%	1.33%	1.94%	0.49%	1.47%	1.95%
TR12	22,580	-1.01%	0.47%	1.26%	-0.19%	1.06%	1.76%	0.66%	1.75%	2.52%	0.74%	1.91%	2.50%
TR13	14,867	-2.33%	-0.54%	0.22%	-1.33%	0.23%	0.86%	-0.54%	0.75%	1.43%	-0.35%	1.08%	1.60%
TR14	34,661	-1.51%	0.10%	0.75%	-0.67%	0.52%	1.17%	0.52%	1.65%	2.28%	0.52%	1.55%	2.10%
National_Urban	344,485	-0.64%	0.83%	1.61%	0.14%	1.27%	1.97%	1.14%	2.25%	3.01%	1.11%	2.22%	2.84%
National_Rural	95,838	-0.65%	0.86%	1.67%	0.14%	1.31%	2.03%	1.17%	2.33%	3.11%	1.15%	2.29%	2.93%
National	440,323	-0.64%	0.84%	1.62%	0.14%	1.28%	1.98%	1.14%	2.27%	3.03%	1.12%	2.23%	2.86%

Source: Simulations results.

Table 14: Per cent change in demand for labour in all sectors across scenarios analysis without and with adaptation (base values in million Dhs)

	BASE	A2_noCO2			B2_noCO2			A2_wCO2			B2_wCO2		
		Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
		Climate change, no adaptation (% change from base)											
Agriculture (crop production)	6,151	-0.09%	0.26%	0.48%	-0.11%	0.10%	0.25%	0.21%	0.30%	0.52%	-0.09%	0.09%	0.12%
Livestock	3,093	-7.70%	-4.43%	-2.43%	-6.24%	-3.26%	-1.53%	-3.99%	-0.92%	1.19%	-3.99%	-0.87%	0.87%
Forestry	130	-1.78%	-0.98%	-0.61%	-1.28%	-0.67%	-0.33%	-0.79%	-0.30%	0.00%	-0.71%	-0.22%	0.03%
Fishery	2,129	-4.41%	-2.54%	-1.47%	-3.40%	-1.85%	-0.90%	-2.27%	-0.80%	0.26%	-2.17%	-0.69%	0.18%
Dairy	115	-4.47%	-2.43%	-1.19%	-3.74%	-1.74%	-0.65%	-1.98%	-0.06%	1.16%	-2.14%	-0.13%	0.86%
Food processing	5,029	-8.37%	-4.65%	-2.61%	-6.38%	-3.48%	-1.67%	-4.26%	-1.17%	0.98%	-4.23%	-1.11%	0.71%
Industry and manufacture	33,568	-2.86%	-1.55%	-0.90%	-2.09%	-1.10%	-0.50%	-1.27%	-0.32%	0.28%	-1.24%	-0.29%	0.23%
Services	105,555	-3.05%	-1.67%	-0.91%	-2.31%	-1.21%	-0.53%	-1.37%	-0.27%	0.46%	-1.37%	-0.28%	0.34%
		Climate change, with adaptation-PMV (% change from base)											
Agriculture (crop production)	6,151	0.02%	0.41%	0.55%	0.07%	0.23%	0.30%	0.30%	0.38%	0.56%	0.01%	0.19%	0.20%
Livestock	3,093	-3.96%	-0.81%	1.08%	-2.51%	0.31%	1.93%	-0.38%	2.48%	4.43%	-0.33%	2.54%	4.15%
Forestry	130	-0.86%	-0.21%	0.07%	-0.40%	0.05%	0.31%	-0.03%	0.28%	0.46%	0.07%	0.36%	0.52%
Fishery	2,129	-1.98%	-0.26%	0.71%	-1.00%	0.37%	1.22%	0.00%	1.26%	2.17%	0.13%	1.38%	2.12%
Dairy	115	-1.71%	0.15%	1.26%	-1.05%	0.76%	1.73%	0.61%	2.29%	3.36%	0.46%	2.21%	3.06%
Food processing	5,029	-2.08%	1.33%	3.20%	-0.21%	2.38%	4.02%	1.75%	4.45%	6.35%	1.79%	4.48%	6.09%
Industry and manufacture	33,568	-0.78%	0.38%	0.94%	-0.07%	0.77%	1.28%	0.67%	1.43%	1.91%	0.71%	1.45%	1.87%
Services	105,555	-0.57%	0.67%	1.34%	0.11%	1.07%	1.68%	0.97%	1.90%	2.53%	0.98%	1.89%	2.42%

Source: Simulations results.

Table 15: Per cent change in demand for capital in all sectors across scenarios analysis without and with adaptation (base values in million Dhs)

		Climate change, no adaptation (% change from base)											
	BASE	A2_noCO2			B2_noCO2			A2_wCO2			B2_wCO2		
		Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Agriculture (crop production)	26,771	-0.33%	0.15%	0.32%	-0.28%	0.03%	0.10%	-0.17%	0.30%	0.45%	-0.32%	0.15%	0.25%
Livestock	6,139	-8.24%	-4.67%	-2.47%	-6.50%	-3.46%	-1.60%	-4.22%	-1.07%	1.21%	-4.18%	-1.00%	0.85%
Forestry & Fishery	4,007	-4.90%	-2.77%	-1.59%	-3.76%	-2.01%	-0.95%	-2.41%	-0.75%	0.41%	-2.34%	-0.66%	0.30%
Dairy	1,291	-9.17%	-5.32%	-3.25%	-6.88%	-4.08%	-2.36%	-5.07%	-2.00%	0.17%	-4.79%	-1.79%	-0.13%
Food Processing	17,104	-9.31%	-5.21%	-2.86%	-7.15%	-3.89%	-1.83%	-4.71%	-1.26%	1.17%	-4.67%	-1.21%	0.83%
Industry & Manufacture	160,811	-4.53%	-2.49%	-1.40%	-3.39%	-1.81%	-0.83%	-2.08%	-0.52%	0.53%	-2.06%	-0.49%	0.40%
Services	35,077	-3.66%	-1.83%	-0.99%	-2.76%	-1.28%	-0.43%	-1.32%	0.17%	0.96%	-1.36%	0.05%	0.79%
		Climate change, with adaptation-PMV (% change from base)											
	BASE	A2_noCO2			B2_noCO2			A2_wCO2			B2_wCO2		
		Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Agriculture (crop production)	26,771	-0.01%	0.01%	-0.09%	-0.17%	-0.30%	-0.47%	-0.33%	-0.26%	-0.34%	-0.50%	-0.46%	-0.56%
Livestock	6,139	-3.88%	-0.49%	1.59%	-2.18%	0.66%	2.39%	-0.03%	2.86%	4.95%	0.04%	2.93%	4.61%
Forestry & Fishery	4,007	-2.05%	-0.11%	0.95%	-0.96%	0.58%	1.51%	0.24%	1.65%	2.62%	0.34%	1.74%	2.55%
Dairy	1,291	-5.23%	-1.51%	0.48%	-2.98%	-0.32%	1.31%	-1.24%	1.63%	3.69%	-0.94%	1.84%	3.38%
Food Processing	17,104	-3.02%	0.82%	2.99%	-0.92%	2.03%	3.91%	1.33%	4.38%	6.56%	1.41%	4.43%	6.24%
Industry & Manufacture	160,811	-1.07%	0.77%	1.73%	0.00%	1.38%	2.24%	1.19%	2.50%	3.39%	1.23%	2.52%	3.27%
Services	35,077	-0.63%	0.99%	1.69%	0.16%	1.45%	2.16%	1.47%	2.71%	3.32%	1.46%	2.58%	3.17%

Source: Simulations results.

Table 16: Per cent change in demand for irrigated land in agricultural sectors across scenarios analysis—without and with adaptation (base values in million Dhs)

		Climate change, no adaptation (% change from base)											
	BASE	A2_noCO2			B2_noCO2			A2_wCO2			B2_wCO2		
		Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Agriculture (crop production)	7,972	-1.20%	-0.20%	0.44%	-1.55%	-0.26%	0.44%	0.21%	1.94%	3.42%	-0.94%	1.14%	2.19%
hdwht-c	290	2.10%	3.15%	1.61%	3.05%	3.01%	2.24%	3.91%	3.69%	1.68%	3.76%	3.13%	2.15%
sfwht-c	772	-1.24%	0.43%	0.58%	-0.41%	0.57%	0.59%	0.58%	1.26%	0.82%	0.48%	1.01%	0.77%
barly-c	344	15.47%	12.28%	9.84%	11.54%	8.89%	6.52%	13.19%	9.30%	6.57%	10.17%	6.72%	3.34%
tomat-c	887	-4.12%	-2.25%	-1.06%	-3.36%	-1.67%	-0.52%	-1.03%	1.13%	2.10%	-1.16%	0.68%	1.50%
xvegts-c	1,169	-3.42%	-1.95%	-1.26%	-2.48%	-1.45%	-1.04%	-2.73%	-1.78%	-1.00%	-2.46%	-1.43%	-0.98%
xvgin-c	33	-3.28%	-2.61%	-2.72%	-2.03%	-2.10%	-2.96%	-6.09%	-7.32%	-7.42%	-4.81%	-5.48%	-6.17%
forags-c	698	6.63%	3.72%	1.30%	8.70%	2.44%	0.47%	1.70%	-4.24%	-6.78%	2.81%	-3.27%	-4.86%
olive-c	203	12.49%	6.63%	5.70%	6.93%	4.29%	4.03%	9.48%	5.35%	4.78%	7.06%	3.18%	2.10%
agrms-c	1,634	-8.27%	-3.65%	-0.06%	-10.15%	-2.71%	1.12%	-0.44%	8.39%	15.85%	-5.32%	5.28%	10.55%
xfruts-c	1,155	3.43%	0.55%	0.38%	0.62%	-0.32%	-0.72%	-1.39%	-0.67%	0.37%	-1.65%	-0.73%	0.07%
xcrops-c	787	-5.53%	-1.67%	-0.85%	-3.25%	-1.22%	-0.29%	-1.18%	0.57%	1.14%	-1.51%	0.26%	0.95%
		Climate change, with adaptation-PMV (% change from base)											
	BASE	A2_noCO2			B2_noCO2			A2_wCO2			B2_wCO2		
		Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Agriculture (crop production)	7,972	14.71%	15.90%	16.74%	13.82%	15.78%	16.73%	16.70%	19.15%	21.20%	14.91%	17.94%	19.40%
hdwht-c	290	5.97%	6.93%	5.29%	6.85%	6.70%	5.85%	7.69%	7.32%	5.20%	7.51%	6.70%	5.63%
sfwht-c	772	-11.15%	-10.97%	-11.50%	-11.16%	-11.47%	-11.93%	-10.75%	-11.13%	-11.94%	-11.09%	-11.65%	-12.19%
barly-c	344	23.26%	19.46%	16.60%	18.91%	15.73%	12.91%	20.50%	15.93%	12.75%	17.26%	13.18%	9.35%
tomat-c	887	-0.60%	0.95%	1.85%	0.11%	1.42%	2.24%	1.65%	3.09%	3.89%	1.57%	2.86%	3.53%
xvegts-c	1,169	-3.50%	-2.39%	-1.97%	-2.79%	-2.01%	-1.78%	-3.02%	-2.36%	-1.82%	-2.82%	-2.06%	-1.81%
xvgin-c	33	3.88%	4.16%	3.77%	4.98%	4.54%	3.38%	0.43%	-1.30%	-1.62%	1.72%	0.63%	-0.29%
forags-c	698	14.53%	11.00%	8.22%	16.50%	9.41%	7.18%	8.92%	2.24%	-0.62%	9.98%	3.16%	1.31%
olive-c	203	-15.66%	-18.61%	-18.88%	-18.57%	-19.85%	-19.84%	-17.00%	-19.09%	-19.12%	-18.42%	-20.33%	-20.66%
agrms-c	1,634	62.46%	69.52%	75.11%	58.59%	70.88%	76.83%	74.90%	88.82%	99.78%	67.14%	83.78%	91.67%
xfruts-c	1,155	8.78%	5.41%	5.06%	5.61%	4.38%	3.83%	3.46%	3.98%	4.92%	3.10%	3.84%	4.56%
xcrops-c	787	1.93%	5.82%	6.52%	4.19%	6.16%	7.01%	6.42%	8.03%	8.48%	5.96%	7.61%	8.23%

Source: Simulations results.

Table 17: Per cent change in demand for rainfed land in agricultural sectors across scenarios analysis—without and with adaptation (base values in million Dhs)

		Climate change, no adaptation (% change from base)											
	BASE	A2_noCO2			B2_noCO2			A2_wCO2			B2_wCO2		
		Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Agriculture (crop production)	11,153	-0.18%	0.39%	0.77%	-0.46%	0.20%	0.49%	0.25%	1.21%	2.12%	-0.46%	0.69%	1.29%
hdwht-c	627	0.47%	1.84%	0.70%	1.72%	1.99%	1.53%	2.41%	2.71%	1.39%	2.33%	2.33%	1.95%
sfwht-c	2,156	-2.47%	-0.25%	0.27%	-1.67%	0.07%	0.48%	0.03%	1.85%	2.13%	-0.37%	1.32%	1.72%
barly-c	544	12.39%	10.15%	8.49%	9.13%	7.35%	5.64%	10.94%	8.20%	6.82%	7.82%	5.87%	3.65%
tomat-c	1,595	-7.87%	-4.60%	-2.16%	-6.94%	-3.44%	-1.13%	-3.13%	0.88%	4.16%	-3.89%	0.28%	2.62%
xvegts-c	2,209	-5.06%	-3.07%	-1.89%	-4.03%	-2.31%	-1.45%	-3.84%	-1.94%	-0.20%	-3.70%	-1.66%	-0.44%
xvgin-c	1,739	-4.96%	-3.73%	-3.35%	-3.61%	-2.95%	-3.37%	-7.20%	-7.53%	-6.76%	-6.04%	-5.73%	-5.70%
forags-c	3,374	5.06%	2.64%	0.71%	7.42%	1.61%	0.03%	0.58%	-4.74%	-6.41%	1.49%	-3.72%	-4.61%
olive-c	2,812	9.85%	5.00%	4.78%	4.90%	3.11%	3.48%	7.78%	4.83%	5.59%	5.05%	2.74%	2.70%
agrms-c	1,934	-12.49%	-6.22%	-1.18%	-14.24%	-4.60%	0.79%	-2.32%	9.44%	20.22%	-8.31%	5.74%	13.35%
xfruts-c	2,241	1.53%	-0.74%	-0.30%	-1.05%	-1.31%	-1.16%	-2.74%	-1.16%	1.11%	-3.21%	-1.19%	0.54%
xcrops-c	13,726	-11.08%	-5.78%	-2.99%	-8.29%	-4.19%	-2.12%	-6.23%	-1.95%	0.50%	-5.55%	-1.65%	0.19%
		Climate change, with adaptation-PMV (% change from base)											
	BASE	A2_noCO2			B2_noCO2			A2_wCO2			B2_wCO2		
		Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
Agriculture (crop production)	11,153	11.76%	12.31%	12.74%	10.96%	11.99%	12.41%	12.52%	13.92%	15.19%	11.26%	13.03%	13.90%
hdwht-c	627	10.60%	12.19%	11.12%	11.60%	12.28%	11.98%	13.00%	13.71%	12.59%	12.54%	13.03%	12.90%
sfwht-c	2,156	-3.31%	-2.24%	-2.25%	-3.53%	-2.62%	-2.49%	-1.75%	-0.54%	-0.39%	-2.72%	-1.57%	-1.23%
barly-c	544	32.24%	29.50%	27.54%	28.21%	26.37%	24.18%	30.92%	27.73%	26.13%	27.06%	25.01%	22.38%
tomat-c	1,595	7.32%	10.90%	13.44%	8.03%	12.04%	14.45%	12.35%	16.54%	20.17%	11.13%	15.80%	18.40%
xvegts-c	2,209	4.09%	6.14%	7.33%	4.78%	6.91%	7.87%	5.68%	7.95%	9.93%	5.45%	8.02%	9.38%
xvgin-c	1,739	12.39%	13.56%	13.86%	13.56%	14.38%	13.81%	9.61%	9.15%	10.10%	10.73%	11.16%	11.21%
forags-c	3,374	21.85%	18.98%	17.05%	24.25%	17.58%	16.30%	17.02%	11.14%	9.56%	17.51%	11.94%	11.16%
olive-c	2,812	-10.12%	-12.26%	-11.65%	-13.09%	-13.18%	-12.30%	-10.17%	-10.89%	-9.32%	-12.43%	-12.40%	-11.54%
agrms-c	1,934	97.79%	110.27%	119.98%	92.54%	113.31%	123.64%	118.77%	143.62%	163.58%	106.97%	135.44%	150.05%
xfruts-c	2,241	15.47%	13.01%	13.61%	12.26%	12.40%	12.77%	11.37%	13.53%	16.33%	10.36%	13.18%	15.30%
xcrops-c	13,726	6.42%	11.89%	14.84%	8.59%	13.47%	15.81%	11.88%	16.88%	19.62%	12.11%	16.79%	18.92%

Source: Simulations results.

Table 18: Selected indicators for the agricultural sector—without and with adaptation (base values in million Dhs)

			A2_noCO2			B2_noCO2			A2_wCO2			B2_wCO2		
		BASE	Low	Med	High	Low	Med	High	Low	Med	High	Low	Med	High
			Climate change, no adaptation (% change from base)											
Agriculture (Production)		75,813	-4.26%	-2.07%	-0.74%	-3.57%	-1.64%	-0.45%	-1.59%	0.68%	2.18%	-2.08%	0.23%	1.38%
Employment	Capital	26,771	-0.33%	0.15%	0.32%	-0.28%	0.03%	0.10%	-0.17%	0.30%	0.45%	-0.32%	0.15%	0.25%
	Labour	6,151	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	LandIr	7,972	-1.20%	-0.20%	0.44%	-1.55%	-0.26%	0.44%	0.21%	1.94%	3.42%	-0.94%	1.14%	2.19%
	LandRf	11,153	-0.18%	0.39%	0.77%	-0.46%	0.20%	0.49%	0.25%	1.21%	2.12%	-0.46%	0.69%	1.29%
Trade	Exports	13,257	-8.95%	-4.43%	-1.32%	-8.15%	-3.15%	0.03%	-1.12%	4.75%	8.47%	-2.89%	3.10%	6.09%
	Imports	13,739	47.82%	26.50%	14.44%	35.55%	20.42%	11.12%	29.56%	13.51%	1.59%	27.89%	11.68%	2.43%
	Exports/Imports	0.96	-38.40%	-24.45%	-13.77%	-32.24%	-19.57%	-9.98%	-23.68%	-7.71%	6.77%	-24.07%	-7.68%	3.58%
			Climate change, with adaptation-PMV (% change from base)											
Agriculture (Production)		52,047	2.35%	8.48%	12.21%	5.17%	10.30%	13.65%	9.95%	15.51%	19.59%	9.44%	15.05%	18.29%
Employment	Capital	26,771	-0.01%	0.01%	-0.09%	-0.17%	-0.30%	-0.47%	-0.33%	-0.26%	-0.34%	-0.50%	-0.46%	-0.56%
	Labour	6,151	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	LandIr	7,972	14.71%	15.90%	16.74%	13.82%	15.78%	16.73%	16.70%	19.15%	21.20%	14.91%	17.94%	19.40%
	LandRf	11,153	11.76%	12.31%	12.74%	10.96%	11.99%	12.41%	12.52%	13.92%	15.19%	11.26%	13.03%	13.90%
Trade	Exports	13,257	13.21%	18.02%	21.29%	13.67%	19.37%	22.73%	21.54%	28.04%	32.19%	19.40%	26.16%	29.44%
	Imports	13,739	33.04%	13.79%	3.49%	21.15%	8.98%	1.18%	16.41%	3.08%	-7.06%	14.93%	1.80%	-6.10%
	Exports/Imports	0.96	-14.91%	3.71%	17.21%	-6.18%	9.53%	21.30%	4.41%	24.22%	42.23%	3.89%	23.93%	37.84%

Source: Simulations results.

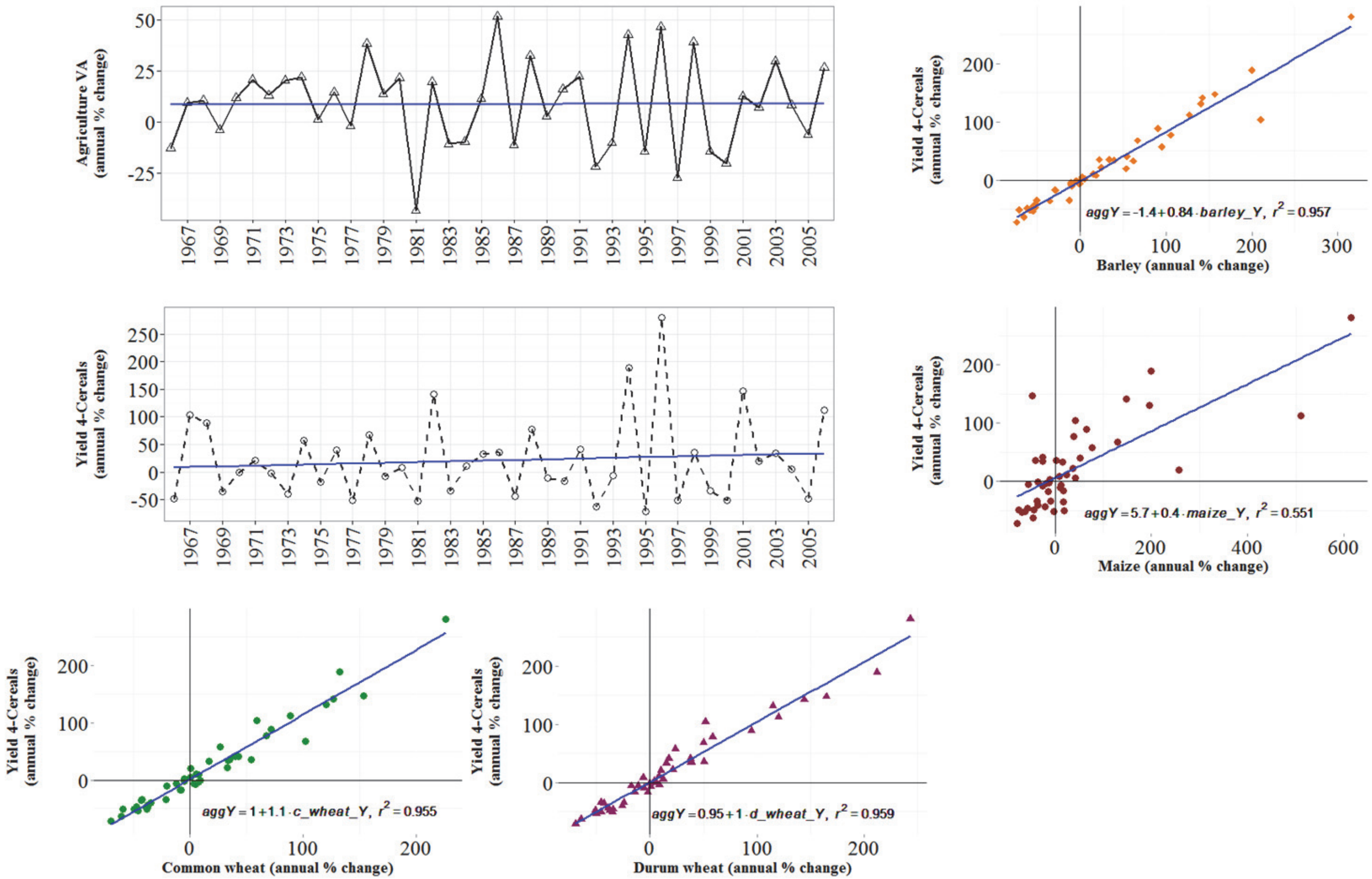
Table 19: Selected indicators for the Food processing sector—without and with adaptation (base values in million Dhs)

		BASE	A2_noCO2 Low	A2_noCO2 Med	A2_noCO2 High	B2_noCO2 Low	B2_noCO2 Med	B2_noCO2 High	A2_wCO2 Low	A2_wCO2 Med	A2_wCO2 High	B2_wCO2 Low	B2_wCO2 Med	B2_wCO2 High
			Climate change, no adaptation (% change from base)											
Food processing		166,078	-4.74%	-2.54%	-1.38%	-3.56%	-1.85%	-0.79%	-2.16%	-0.44%	0.72%	-2.16%	-0.44%	0.55%
Employment	Capital	17,104	-9.31%	-5.21%	-2.86%	-7.15%	-3.89%	-1.83%	-4.71%	-1.26%	1.17%	-4.67%	-1.21%	0.83%
Trade	Exports	5,733	-10.20%	-5.46%	-3.51%	-6.93%	-4.00%	-2.40%	-5.98%	-2.56%	-0.65%	-5.23%	-2.00%	-0.22%
	Imports	10,643	1.27%	0.56%	0.33%	0.64%	0.40%	0.30%	0.98%	0.64%	0.38%	0.77%	0.45%	0.23%
	Exports/Imports	0.54	-11.33%	-5.98%	-3.83%	-7.52%	-4.39%	-2.70%	-6.90%	-3.18%	-1.03%	-5.95%	-2.43%	-0.45%
			Climate change, with adaptation-PMV (% change from base)											
Food processing		166,078	-1.85%	0.16%	1.21%	-0.74%	0.78%	1.72%	0.52%	1.99%	2.99%	0.56%	2.00%	2.85%
Employment	Capital	17,104	-3.02%	0.82%	2.99%	-0.92%	2.03%	3.91%	1.33%	4.38%	6.56%	1.41%	4.43%	6.24%
Trade	Exports	5,733	-2.74%	1.17%	2.82%	0.04%	2.33%	3.68%	0.84%	3.41%	4.91%	1.52%	3.85%	5.26%
	Imports	10,643	3.19%	2.75%	2.51%	2.79%	2.64%	2.52%	3.10%	2.88%	2.62%	2.94%	2.72%	2.50%
	Exports/Imports	0.54	-5.74%	-1.53%	0.30%	-2.68%	-0.30%	1.13%	-2.19%	0.51%	2.23%	-1.38%	1.10%	2.70%

Source: Simulations results.

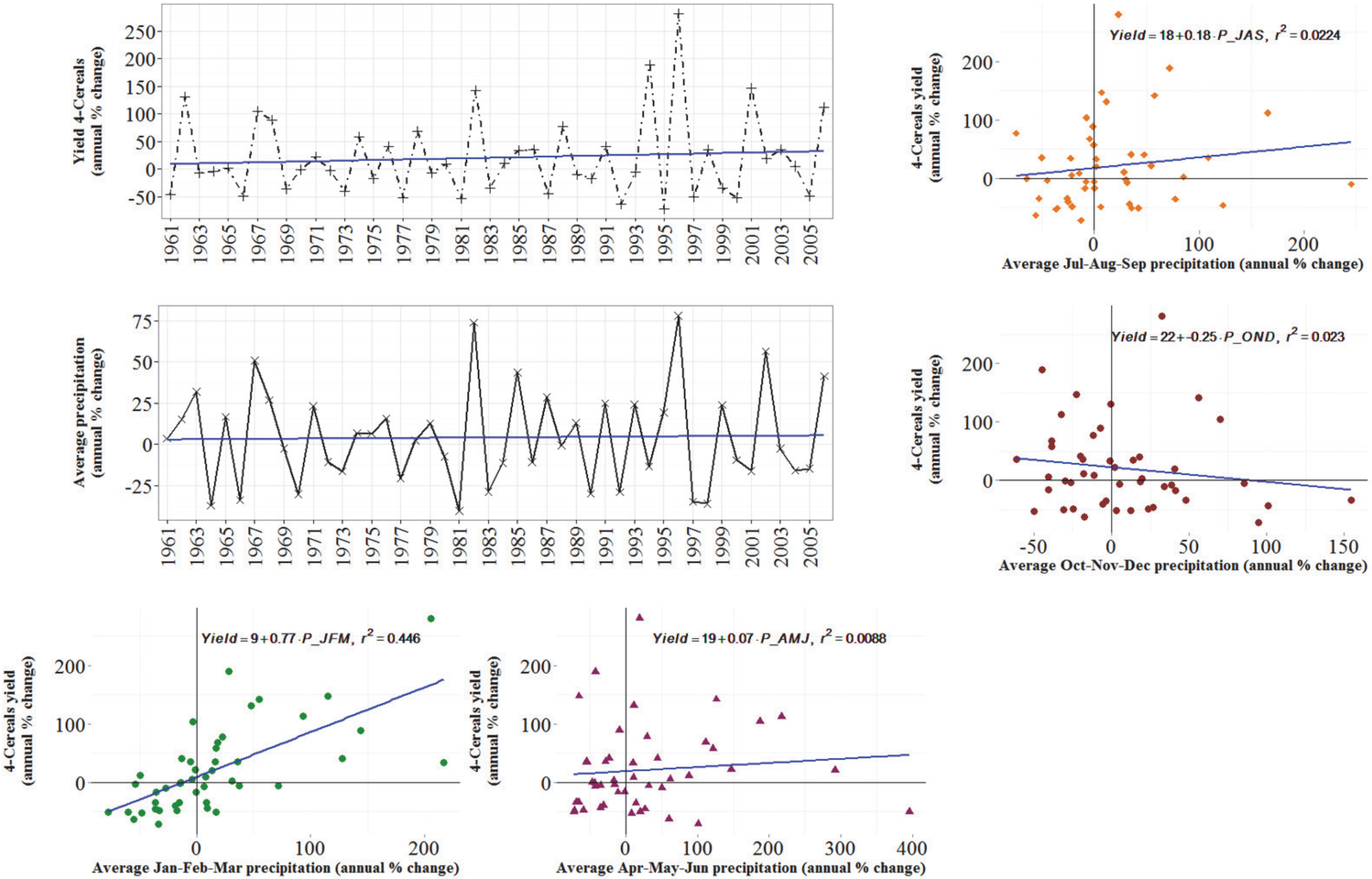
APPENDIX B: Figures

Figure 1: Evolution of agricultural value-added and the four main cereals production (in annual % change) and correlations across cereal production (1960-2006)



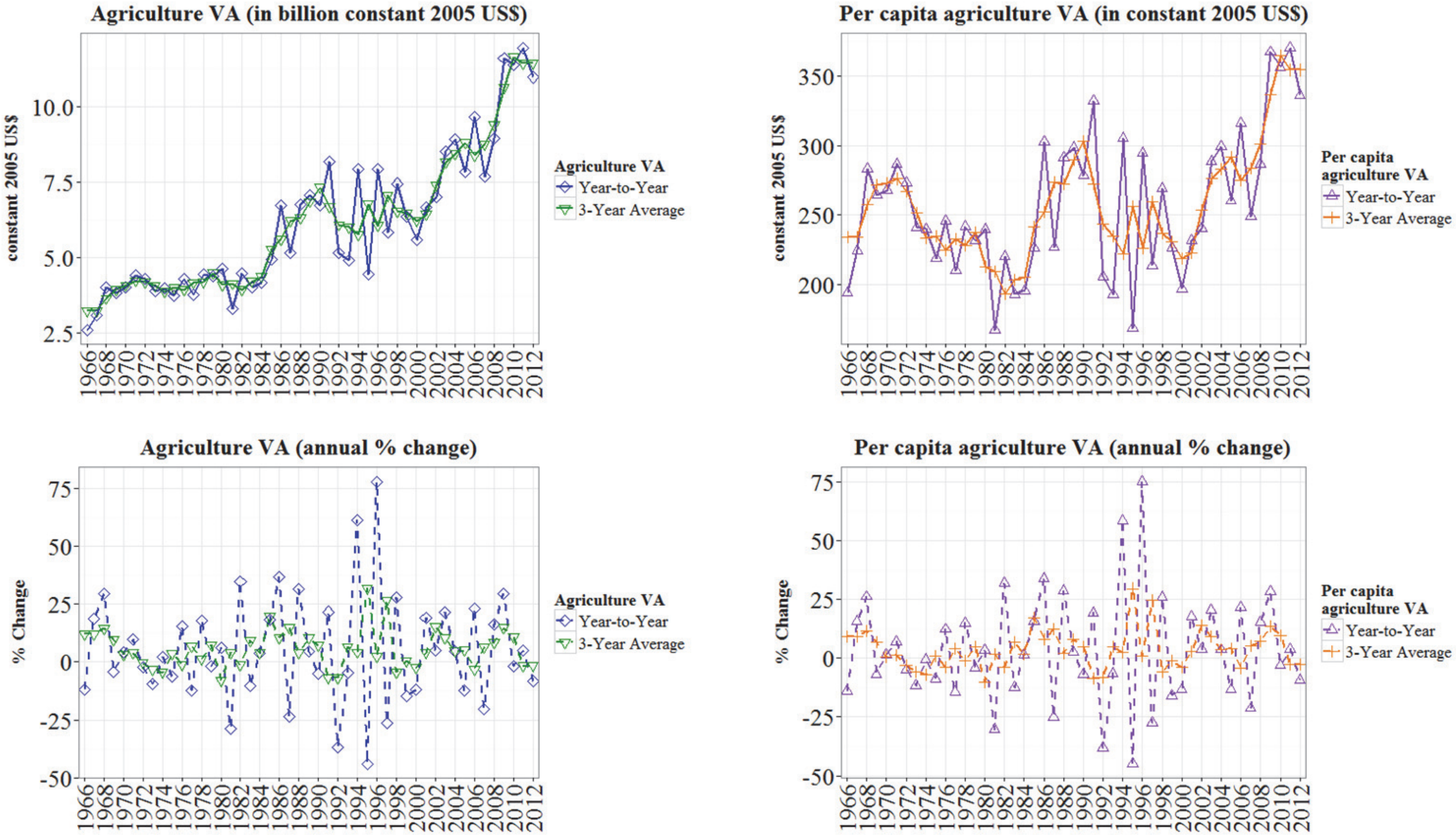
Source: Authors' adaptation based on World Bank (2014).

Figure 2: Evolution of cereals yields and average precipitation (in annual % change) and seasonal correlation (1960-2006)



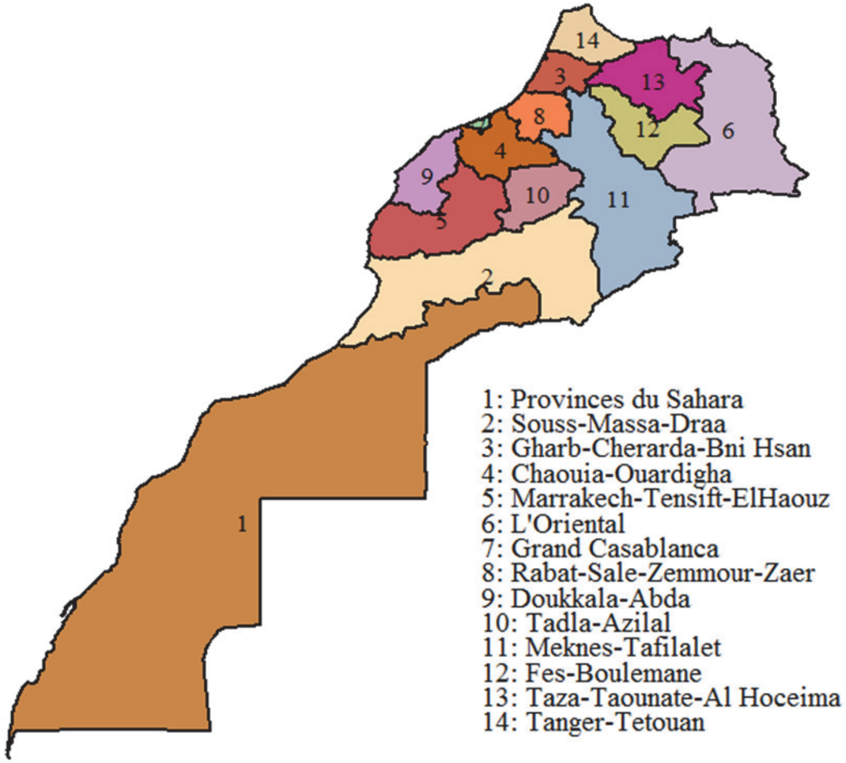
Source: Authors' adaptation based on World Bank (2014).

Figure 3: Evolution of annual per cent changes in agriculture value-added and agriculture value-added per capita (in constant 2005 US$)



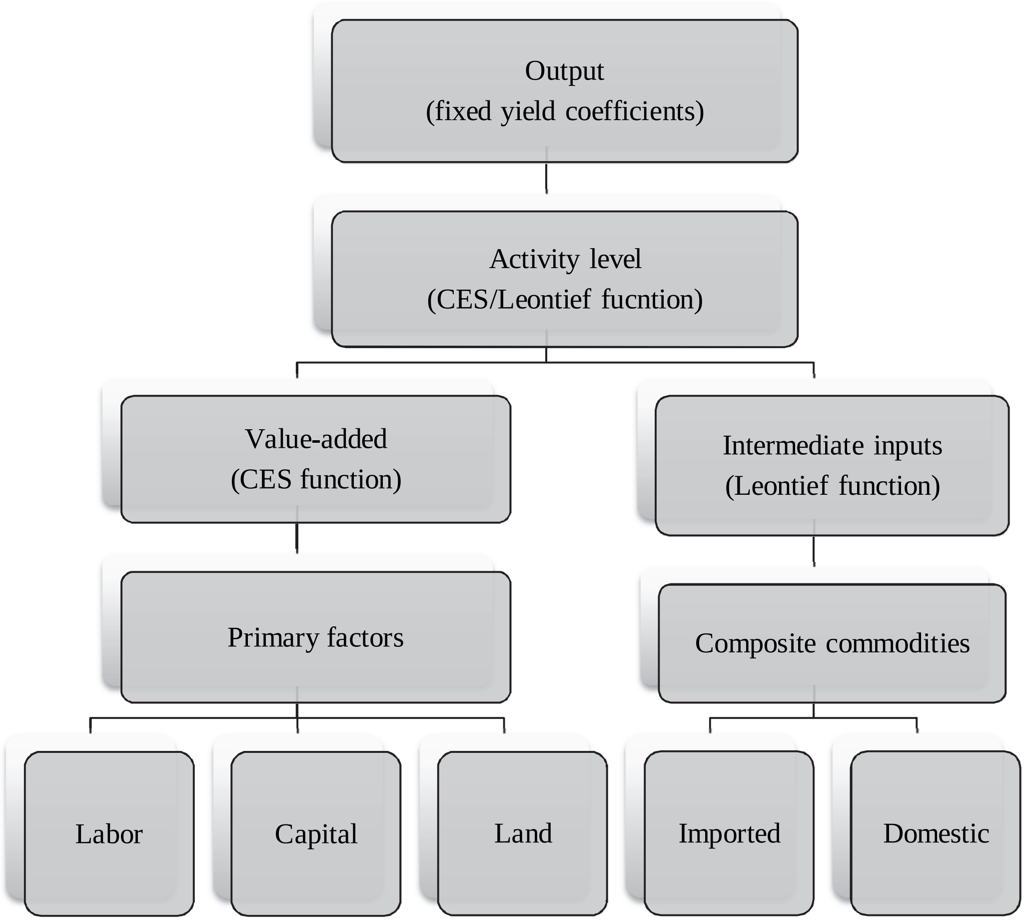
Source: Authors' adaptation based on World Bank (2014).

Figure 4: Administrative and economic regions in Morocco



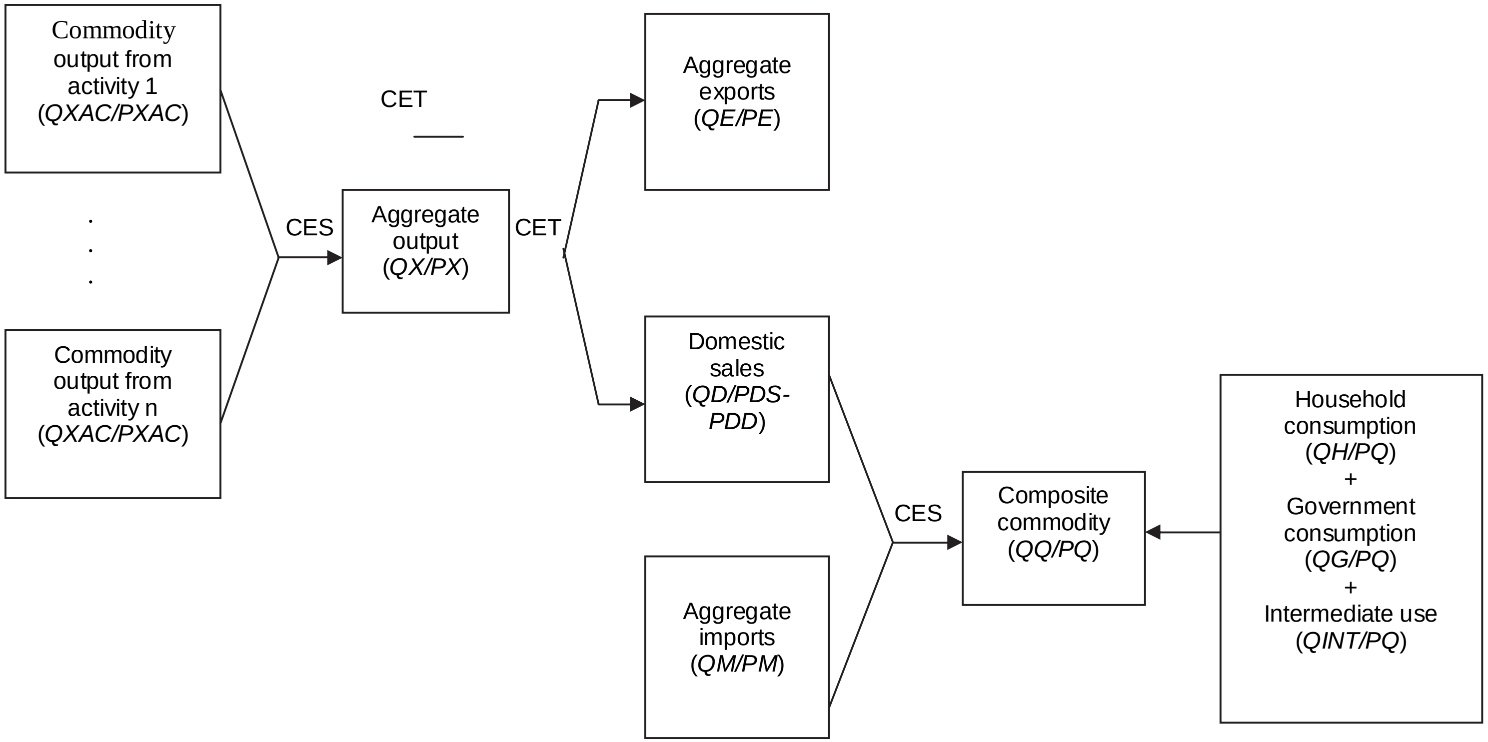
Source: Authors' construction.

Figure 5: Production technology



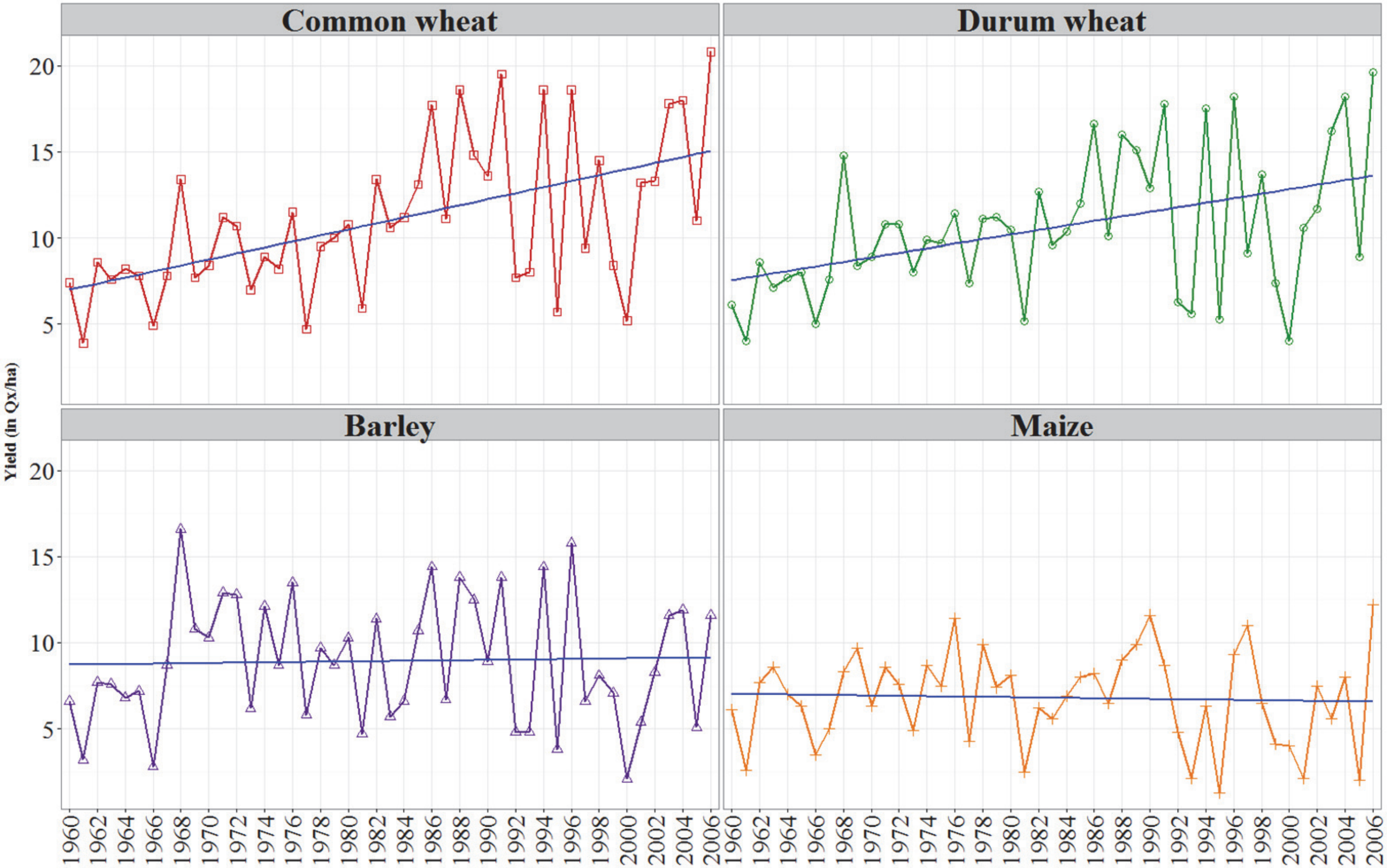
Source: Authors' adaptation based on Lofgren et al. (2002).

Figure 6: Flows of marketed commodities



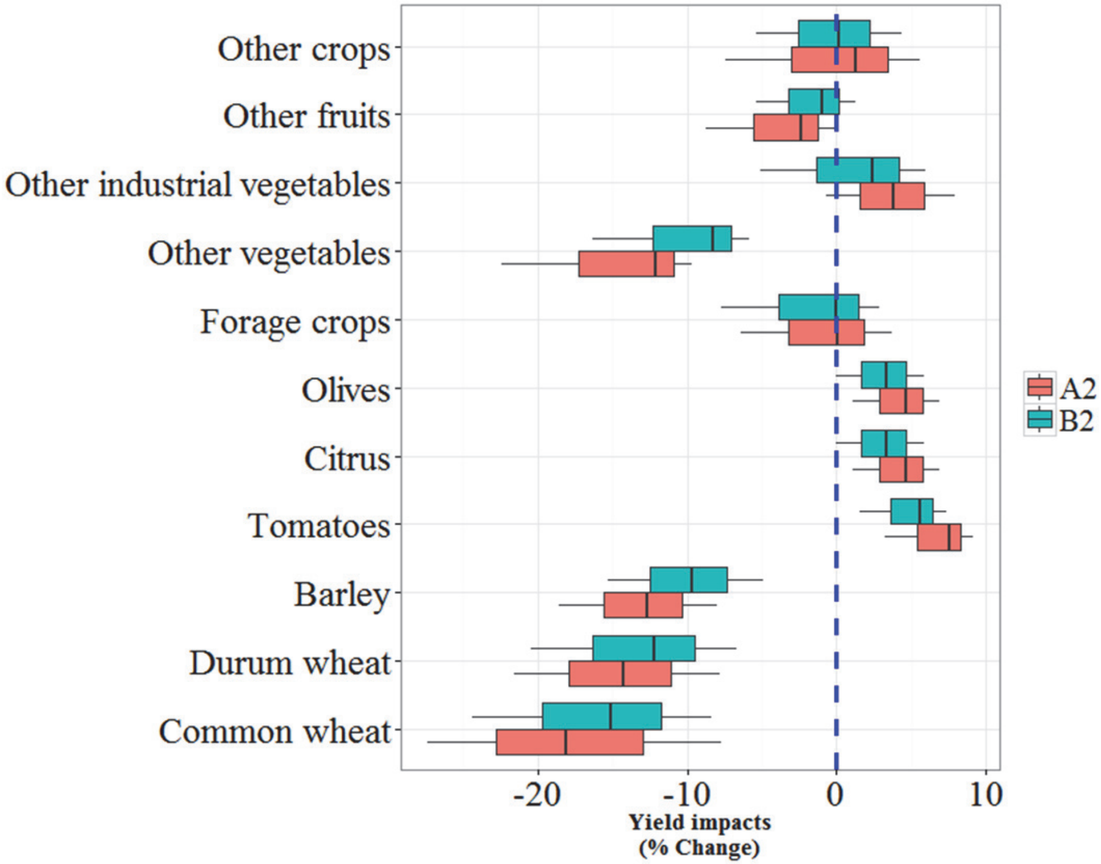
Source: Authors' adaptation based on Lofgren et al. (2002).

Figure 7: Evolution of common wheat, durum wheat, barley, and maize yields for the period 1960-2006



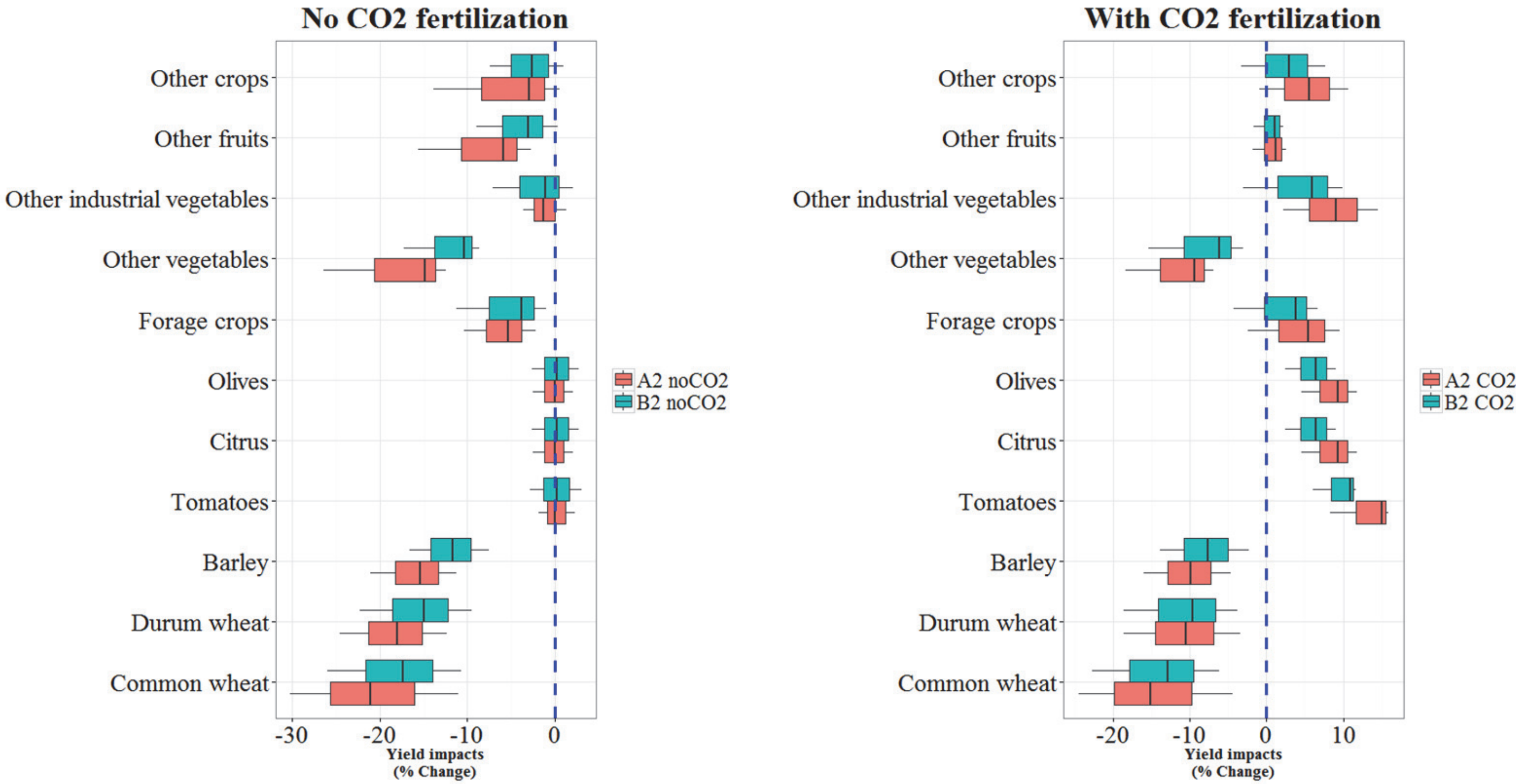
Source: Authors' adaptation based on World Bank (2014).

Figure 8: Projected yield impacts at the national level for SRES A2 and B2



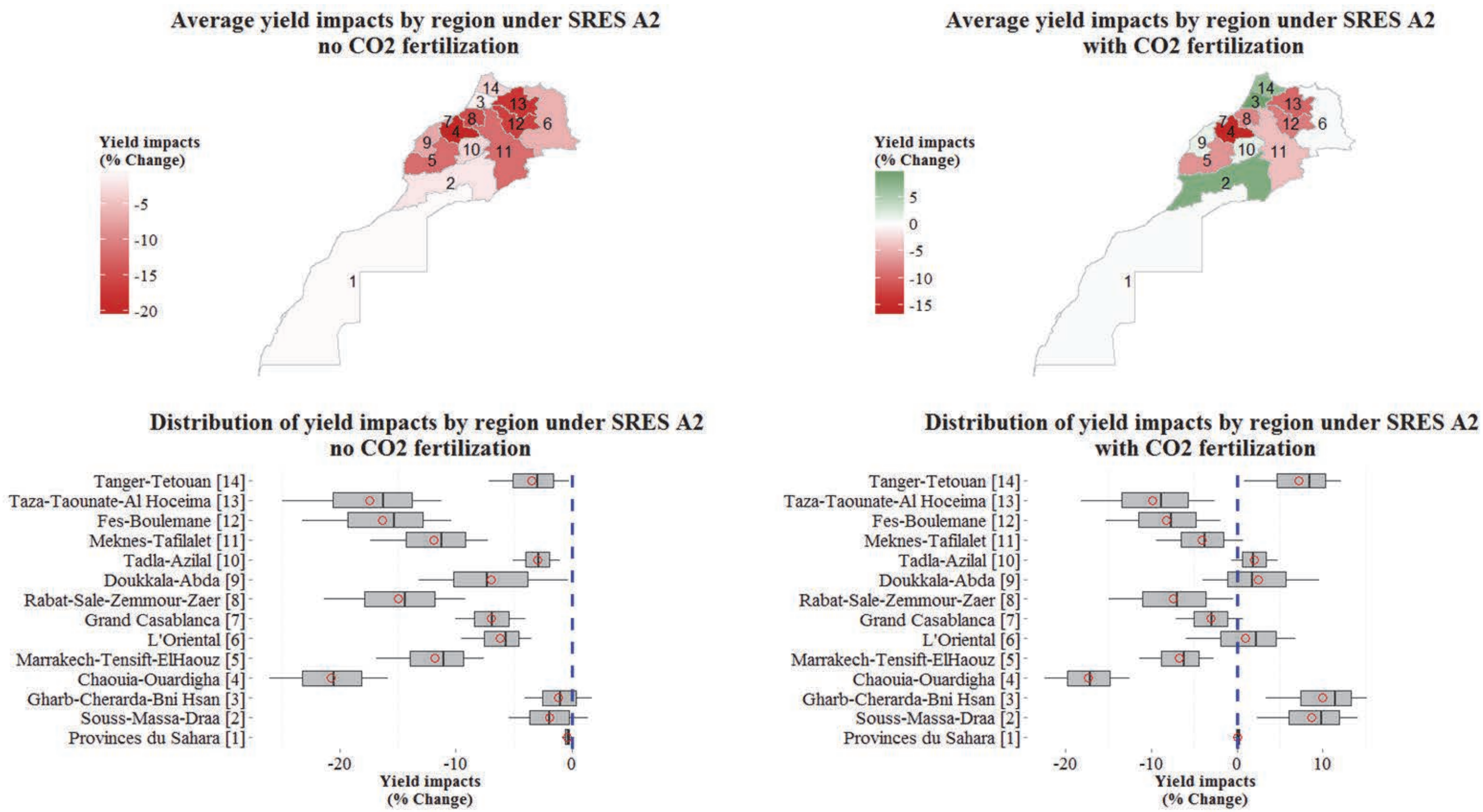
Source: Authors' adaptation based on the study of WB/Morocco/FAO (Gommes et al. 2009).

Figure 9: Projected yield impacts at the national level for SRES A2 and B2 with and without CO2 fertilization effects



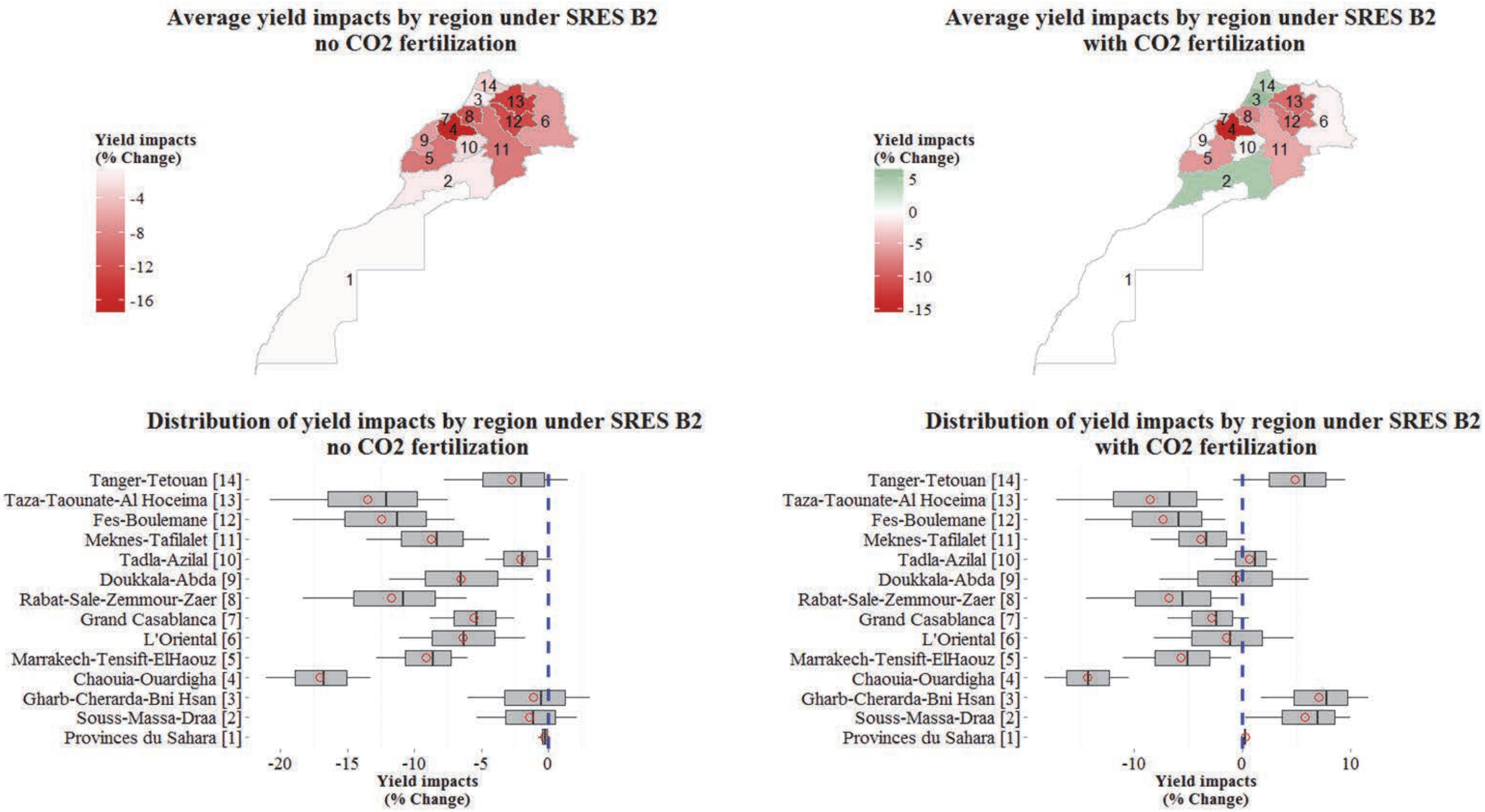
Source: Authors' adaptation based on the study of WB/Morocco/FAO (Gommes et al. 2009).

Figure 10a: Regional distribution of average projected yield impacts across crops under the SRES A2 by region



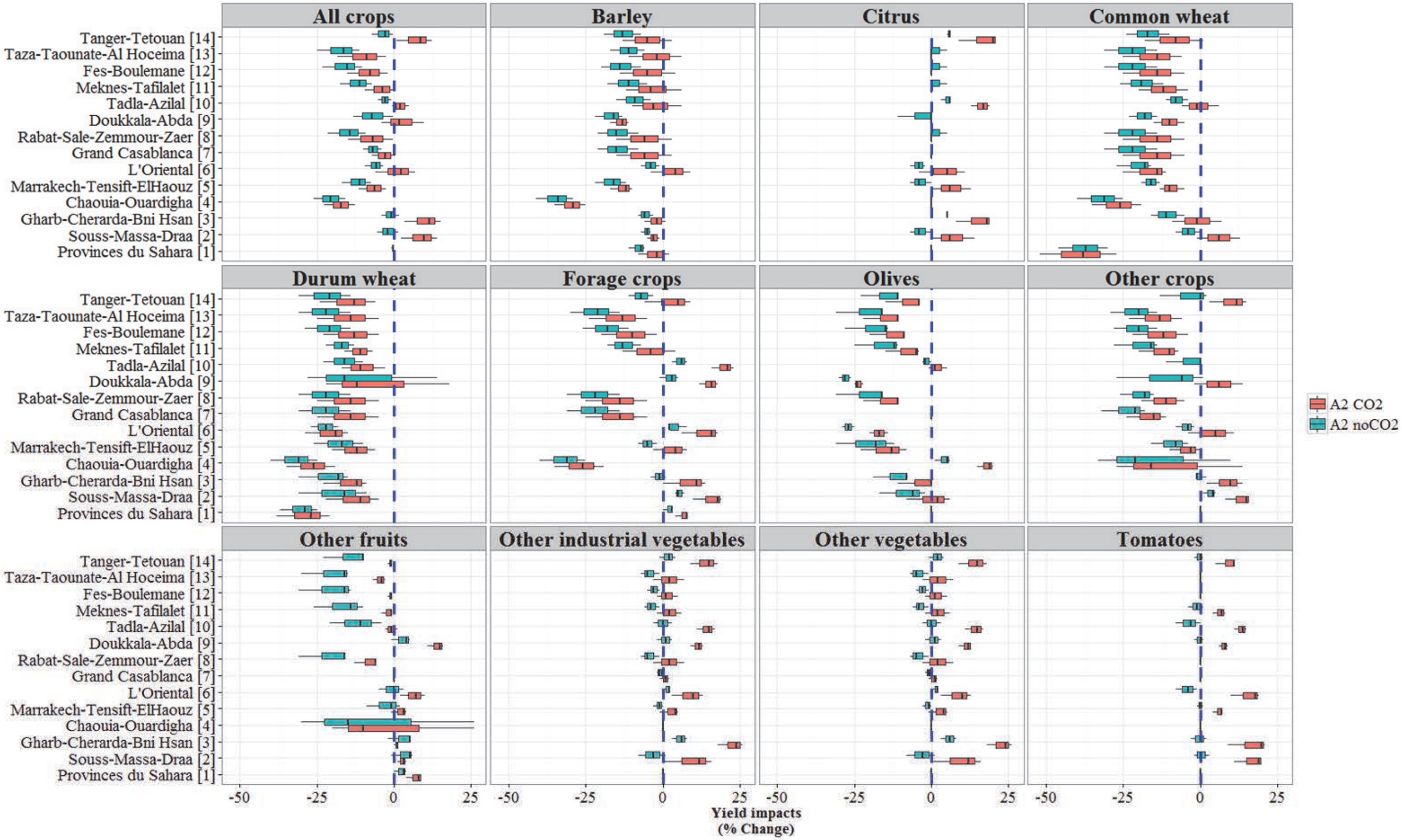
Source: Authors' adaptation based on the study of WB/Morocco/FAO (Gommes et al. 2009).

Figure 10b: Regional distribution of average projected yield impacts across crops under the SRES B2 by region



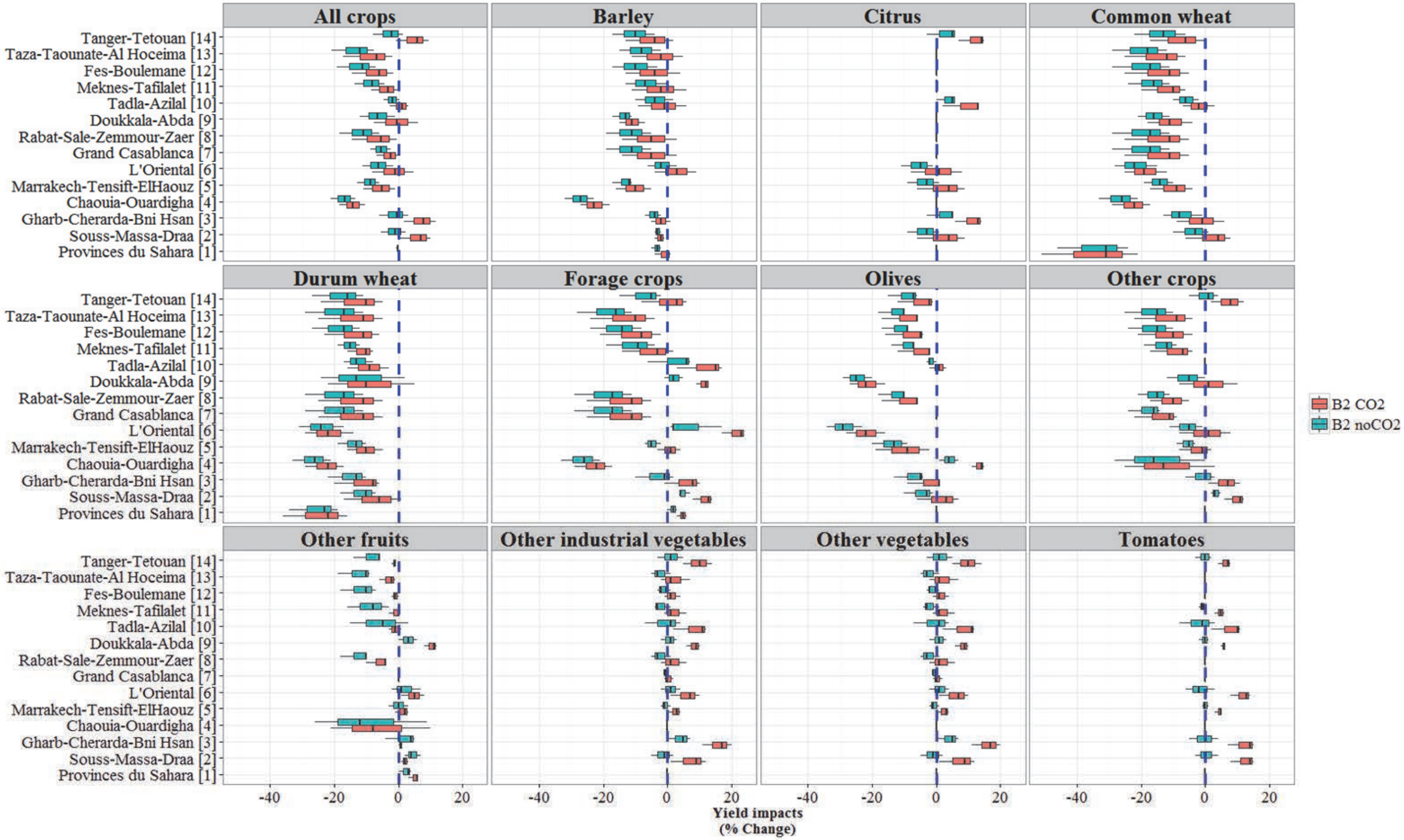
Source: Authors' adaptation based on the study of WB/Morocco/FAO (Gommes et al. 2009).

Figure 11a: Distribution of projected yield impacts in Morocco by crop and by region under SRES A2 with and without CO2 fertilization effects



Source: Authors' adaptation based on the study of WB/Morocco/FAO (Gommes et al. 2009).

Figure 11b: Distribution of projected yield impacts in Morocco by crop and by region under SRES B2 with and without CO2 fertilization effects



Source: Authors' adaptation based on the study of WB/Morocco/FAO (Gommes et al. 2009).