Impact of climate change on households' welfare in Burkina Faso. Welfare decomposition analysis

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ABSTRACT

This article investigates the effects of climate-induced agricultural shocks on household welfare in Burkina Faso using a combination of the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT), and the Global Trade Analysis Project (GTAP) standard model. The climate shocks such as temperature variation and precipitation are converted to agricultural shocks using the IMPACT model which is a partial equilibrium model. Later on, these climate-induced agricultural shocks are introduced into the (GTAP) standard model to evaluate households' welfare effects. The simulations show that climate-induced agricultural shocks (agriculture yield decrease and the cropland variation) will reduce households' global wellbeing in Burkina Faso. For instance, the results show that climate change will cause a minimum GDP loss estimated at 9.33% and a maximum loss estimated at 17.39% in Burkina Faso. Besides, simulations demonstrate that climate shocks will lead to an average household welfare loss estimated to 14% in Burkina Faso. These results are in line with theoretical intuition showing a deterioration in households' welfare.

Keys words: Climate change, Impact, CGE models, Burkina Faso, welfare

JEL: Q54, D58, E16, I31, R22

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Introduction

Burkina Faso is one of the African countries already affecting by climate changes. In this country, climate change manifests by a gradual decline in the length of the rainy season, frequent droughts, floods, heatwaves, and dust storms. According to González et al. (2011), in Burkina Faso, the effects of climate change are such that *"in a single area, it can be observed both floods and drought within a few months*." The country will be remarkably affected since its economy is mainly rural and based on the agriculture sector. The farming sector of the country is less developed and practicing in small areas. It is dominated by rainfed agriculture, representing more than 90% of the exploited areas (Zidouemba, 2017). In the country, a good agriculture season is conditioning by good rainfall and ideal temperature. As a result, climate change will significantly affect this agriculture sector. These facts associated with the absence of technology make the country very vulnerable to climate change and constitute a significant problem for achieving food security and reducing poverty.

Therefore, it is essential to assess climate change effects and identify adaptation and mitigation strategies. However, investigating the climate change implication in Burkina Faso is not well analyzed in the literature. Among the existing studies, Ouedraogo et al. (2006) assess climate changes' impact on the agriculture sector in Burkina Faso using the Ricardian method. Their research shows that a marginal increase in temperature will decrease agricultural revenue by US$19.9 per hectare. The Ricardian approach adopted in their study is however a crop model focusing only on production and hence presents some limits as it overvalues climate change costs, (Arndt et al. 2015). Zidouemba (2017) uses a CGE model to analyze the economic effects of climate change in Burkina Faso. Assuming that rainfall variability and crop yields decline will be the direct physical effect of climate change, he finds that climate change will reduce national welfare. Besides, his study shows that the magnitude of the impacts varies according to the climate scenario considered. Zidouemba's (2017) study presents some limits since the climate change effects on crop yields are based on assumptions without an empirical estimation.

To address some of the limitations of the above studies, this paper uses a new methodology to estimate the climate change welfare effect in Burkina Faso. It consists of estimating the magnitude of climate change's impact on household welfare in Burkina Faso using a methodology linking the IMPACT model-generated shocks to the GTAP model.

The simulations show that the decrease of agriculture yield and the variation of cropland due to climate change will lead to a decline of households' global wellbeing in Burkina Faso. For instance, the results show that climate change will cause a minimum GDP loss estimated at 9.33% and a maximum loss estimated at 17.39% in Burkina Faso by 2050. Besides, the study reveals that climate shocks will cause an average regional household welfare loss estimated at 14% in Burkina Faso. To our knowledge, it is the first time that a study precisely quantifies the climate shock effect in terms of welfare loss in Burkina Faso, and the results can be used in public policies to mitigate the climate change effect.

The rest of the paper is structured as follows: Section I presents the state of climate change in Burkina Faso. Section II reviews the literature about climate change's effect on welfare. Section III displays the methodology adopted in this paper, and section IV describes the scenarios used for the simulation. Finally, in section V we display the outcomes of the simulations.

1. State of climate change in Burkina Faso

Climate change in Burkina Faso is manifesting by a continuous variation of temperature levels, precipitation irregularities, and frequent drought, floods, and heatwaves.

The temperature level in Burkina Faso has risen in the last 50 years. For instance, Oueslati et al. (2017) and De Longueville et al. (2016) show that temperature levels have experienced a positive variation respectively since 1959 and between 1950 and 2013. Figure 1 displays the monthly temperatures level in 1901 and 2016. It shows that compared to 1901, the temperature levels have increased for all the months in 2016. The increase is particularly higher for March, April, and May, which are the hotter months in Burkina

Faso. According to projections, this upper trend of temperatures will continue in the following years. World-Bank, (2011) predicts that temperatures level will increase by 3 to 4°C in the decade of 2080-2099 from their level of 1980-1999 in Burkina Faso.

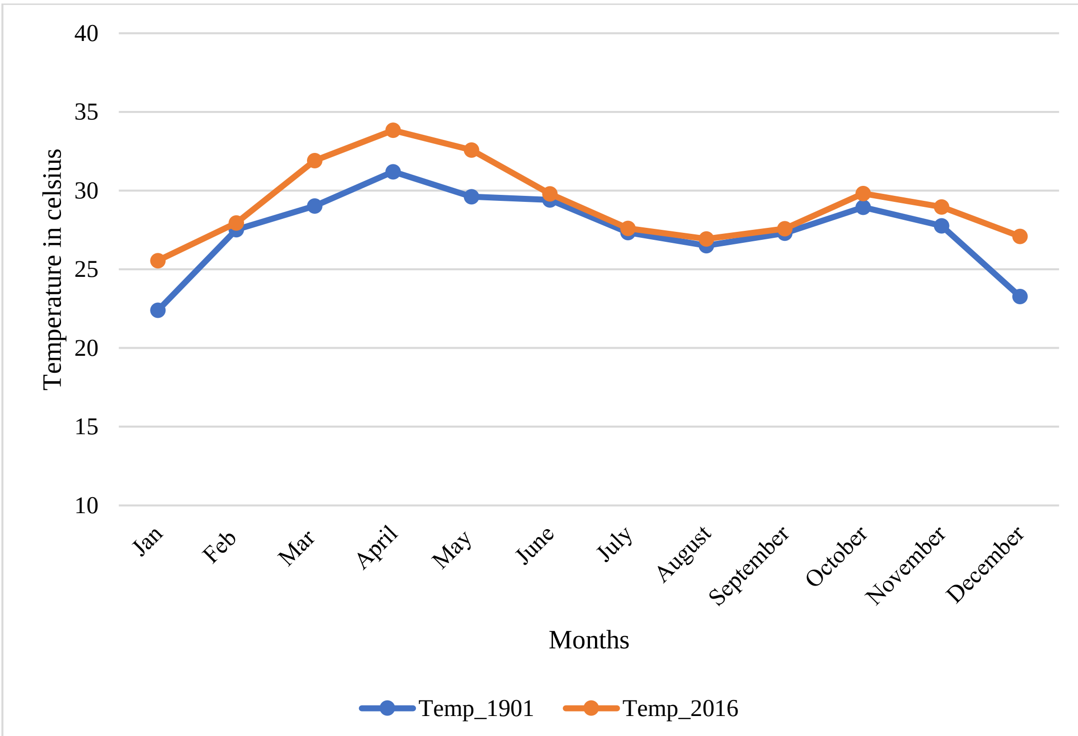

Figure 1*: Average monthly temperature in Burkina Faso 1901 and 2016*

Source: *Built by the author using World Bank (2020) data*

For the rainfall level, Figure 2 below presents the evolution of average rainfall during the rainy season, which covers May, June, July, August, and September. It shows a downward trend in rainfall level since 1960 for all the months except August. August, the rainiest month in Burkina Faso, is experiencing a smooth evolution of its rainfall level, with a rising global trend. For the month of May, there is a steady decline in the average quantity of rainfall since 1992 indicating a late start of the rainy season in recent decades. For the other months, there is a sawtooth trend with a slight downward trend. However, although climate change has not yet had a substantial effect on the quantity of rainfall, it has had many consequences on the distribution of rainfall over time and space. Studies have examined the effect of climate change on rainfall in Burkina Faso. For instance (De Longueville et al., (2016) discovered that from 1950 to 2013, the total volume of rain in Burkina Faso has a decreased. Indeed, all stations analyzed in their studies show a decreasing trend, with more than 50% of the stations having statistically significant decreasing trends. Boureima, Sie and, Germain, (2017) have for their part noticed a downward trend in the mean rainfall level in the city of Bobo Dioulasso and an upward trend in Ouagadougou and Dori.

Also, climate change has caused many rainfall-related disasters such as floods and droughts in recent years. These effects constitute a significant problem for the country and particularly for the agriculture sector. Droughts and floods are obstacles to agriculture production and food security due to their negative impacts on soil quality and crop productivity.

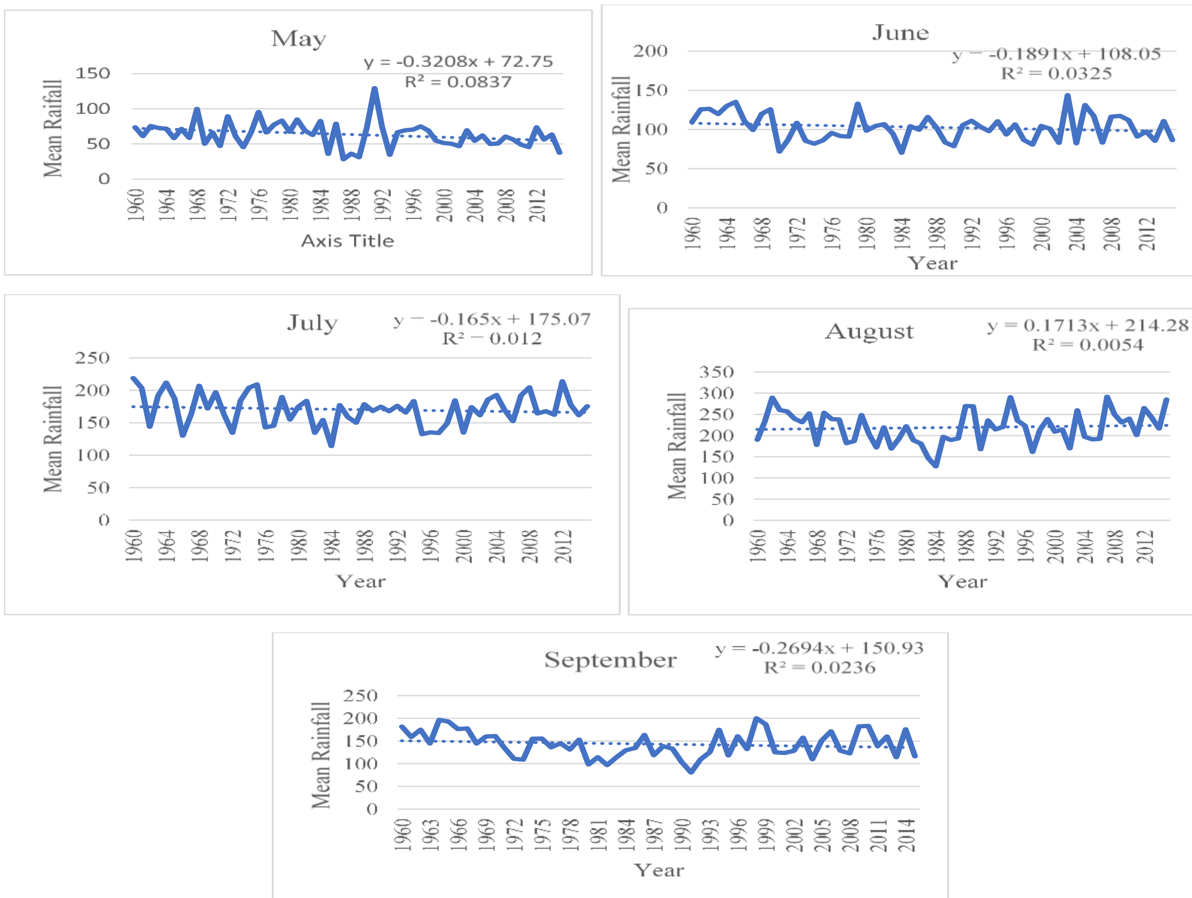

Figure 2: *Average Monthly rainfall in Burkina Faso in 1901 and 2016*

Source: *Built by the author using World Bank (2020) data*

2. Literature review

This section reviews the empirical studies on the influence of climate change on households' welfare. There are two types of research in the literature related to climate change effects on households' welfare: quantitative studies that have examined the impact of climate shocks on consumption, income, and household health, and other studies that analyzed the effect of global warming on households' subjective well-being.

2.1.Quantitative studies

Households' consumption and income have been the focus of many studies related to climate change's impact on household welfare. The Ricardian model, the hedonic model, and econometric estimations are generally used to evaluate climate change's impact on productivity, production, and farm income. Skoufias & Vinha, (2012), analyzing climate shocks' impacts on households' welfare in Mexico find that climate change only affects households living in municipalities with a dry climate. When they examine all the samples together, the analysis shows a non-significant impact of climate change on food and non-food consumption. Therefore, they conclude that climate change's effects on households' welfare are related to the nature of the regional climate. Kabubo-mariara et al., (2016) use a panel data method to examine the climate change impact on food production and poverty in Kenya. Their study reveals a non-linear impact of weather factors and food production, and the risk of food insecurity. Their study also finds a positive relation between humidity and food production until an optimal point. Furthermore, they show that the use of new technology and market access are possible climate change adaptation and mitigation strategies. Mulatu et al., (2016) using a Computable General Equilibrium (CGE) model, find that global warming negatively impacts agriculture productivity and households' welfare in Ethiopia. Indeed, they find that climate change will reduce Ethiopia's GDP by 4.5 percent. Schlenker et al., (2010) use a panel data analysis to demonstrate that climate change will negatively affect agricultural production in Sub-Saharan Africa (SSA). For instance, their results reveal that crops such as maize, millet, sorghum, cassava, and groundnut production will respectively decrease with a rate of −22, −17, −18, −8%, and −17 by the mid-century. Besides, their study shows that African countries experiencing high agricultural yields will be the most affected. Hirvonen, (2016) examines the impact of temperature change on households' consumption in Tanzania. He shows that temperature level in the growing season is negatively correlated with households' consumption per capita. For instance, he reveals that a 1% increase in the average monthly temperature leads to a decline of the average per capita consumption in Tanzania estimated between 4.9 and 5.5%. Marx & Espagne, (2019) examine the impact of climate variability on households' income in Vietnam using a non-linear model. They demonstrate that the number of days with a temperature level above 33°c is negatively correlated with yearly income. For example, one more day with a temperature above 33°C is associated with a decrease of 1.3% of households' annual income. Using a climate change projection, they show that global warming could lead to a 100% loss of households' income by 2099 in some regions of Vietnam. For their part, Arndt et al., (2015) evaluate the implication of climate change in Ghana using a CGE model. They find that climate change adversely affects Ghana's economy, particularly the agriculture sector. Indeed, their simulations show that climate change will reduce Ghana's GDP by 1.9%. However, they reveal that these impacts vary widely across scenarios and regions.

To summarise most of the previous quantitative studies analyzing the impact of climate on household welfare have focused on agricultural production and consumption's effects. Also, the climate change impact on households welfare is negative in these studies.

2.2.Effect of climate change on households' subjective wellbeing

Many approaches were developed to examine the impact of climate change on households' subjective wellbeing. Hedonic approach and subjective life satisfaction are generally combined to analyze the effects of climate change on welfare. Life satisfaction is an indicator of wellbeing computed with survey data, where it is generally asked participants to evaluate their current life situation in a range of a given interval. The hedonic approach assumes that goods' values are estimating according to utilities and characteristics (Rosen, 1974). Therefore, in studies (Rehdanz & Maddison, (2009); Nakic et al., (1996); Rehdanz (2006)) the climate variables are included as factors that affect life satisfaction indices. Rehdanz & Maddison (2005) use cross-national data and control for other factors to show that temperature and rainfall significantly affect subjective wellbeing.

Alem & Colmer (2013) evaluate the cost of change variability in terms of households' subjective welfare in Ethiopia. They combined atmospheric data with panel data collecting in rural Ethiopia to demonstrate that the uncertainty related to climate variability reduces households' subjective wellbeing. Also, they show that one standard deviation of climate change causes a decline in life satisfaction corresponding to a 2% decrease in consumption. Möllendorff & Hirschfeld (2016), for their part, evaluate the effect of extreme weather events on life satisfaction. Using a fixed-effect model, they find that extreme events such as flood, hail, and storm conduct to a small decline in life satisfaction ranging from 0.020–0.027 on a scale of 11.

Maddison & Rehdanz (2010) evaluate the impact of climate change on life satisfaction in 87 countries using the World Value survey data. They find that climate shocks negatively influence African countries, while Northern Europe will gain modest satisfaction. Carroll et al. (2009), using a hedonic technique with a fixed effect estimation method, find that drought in springs negatively affects life satisfaction, corresponding to an annual income reduction of A$18,000 in Australia. Nakic et al. (1996) used the hedonic method to examine the impact of doubling CO_2 on climate amenities in the USA. The study reveals that a doubling of CO_2 will decrease climate amenities, which corresponds to 0.17% of the USA's GDP. Similar to studies using household consumption and production, the studies using subjective indicators find negative effect of climate change on households welfare.

2.3. Impact of climate change on households' welfare in Burkina Faso

The investigation of the climate change implication in Burkina Faso is not well analyzed in the literature. The existing studies have focused on analyzing global warming impacts on the agricultural sector and food security. For instance, Ouedraogo et al. (2006) evaluate the impact of climate shocks on agriculture production in Burkina Faso using the Ricardian method. Their research shows that a marginal increase in temperature will result in a decrease in agriculture revenue of $19.9 per hectare, while an additional decrease of 1mm a month of precipitation will result in a loss of US$ 2.7 per hectare in farming revenue. Besides, they demonstrate that irrigated crops are less sensitive to rainfall and more vulnerable to temperature than non-irrigated farms. Their findings are in line with the Siégnounou (2011)'s report. Indeed, Siégnounou (2011) points out no link between water resource availability and crop production. However, there is a correlation between irrigated production, temperature, and rainfall in the Ouahigouya region located in the north of Burkina Faso.

Oueresse (2009), meanwhile, estimated the effect of climate change on the cotton crop in a village in the western part of Burkina Faso. His research shows that the insufficiency of rainfall leads to a significant drop in cotton farmers' income. In the same vein, Diarra et al. (2017) examine climate change's impact on cotton production in Burkina Faso. They show that both temperature and precipitation variation will negatively influence the yield of cotton in Burkina Faso. However, the effect of temperature will be relatively higher than the effect of rainfall.

Zidouemba (2017) uses a CGE model to analyze the economic impact of climate change in Burkina Faso. By assuming that climate change will increase rainfall variability and crop yields decline, he finds that the total effect of global warming will be a reduction of national welfare, with rural households being the more affected. Also, he reveals that the extent of climate change's impact is a function of the climate scenario considered. Another study by Zidouemba (2017b) employs a CGE model to evaluate climate shocks' impact on households' food security in Burkina Faso. His simulations reveal that rural households and urban low-income households will be the most affected by global warming in Burkina Faso.

In this paper, we contribute to this literature by examining the effect of climate change on households' welfare in Burkina Faso using a novel methodology to link the IMPACT model-generated shocks to the GTAP standard model.

3. Methodology and model specification

Economic modeling of the climate change impact is very challenging because, it requires a quantitative investigation of a wide range of environmental, economic, and social (Stern & Britain, 2007). Many approaches have been developed, for evaluating the economic and social impact of climate change. Among, those approaches, we have the Computable General Equilibrium CGE models which are nowadays widely used in the literature on climate change impacts. Computable General Equilibrium (CGE) models are for origin the Leon Walras' general theory of equilibrium developed during the nineteenth century. In recent decades, there has been a rapid growth in the use of the CGE models with an extension in many domains. For instance, nowadays these models are used to solve a wide variety of issues that range from studying the effects of exogenous shocks and the impacts of specific policies on overall welfare. The use of CGE models has been extended to assess the effects of climate change, where they are used to estimate the overall economic impacts of climate change, considering the interactions between economic agents and activities. CGE models are also used to analyze the mitigation and adaptation policies and to evaluate the effect of CO2 reduction agreements (Böhringer et al, 2012).

In this paper, we propose a novel methodology that consists of combining a partial equilibrium model and a general equilibrium model to analyze climate change's impact on welfare. In the first step, the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) which is a partial equilibrium model is used to generate climate change agricultural shocks. In the second steep, these generated agricultural shocks are included in the GTAP standard model, to simulate the households' welfare effect of climate change. Finally, using the welfare decomposition method integrated into the GTAP model to investigate the sources of welfare change following the climate shocks.

3.1.IMPACT model

The International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) is a partial equilibrium model, which uses a system of supply and demand equations to analyze food production, food demand and prices, trade, income, and the population at the national and international level. The first version has been developed at the beginning of the 1990s. The version using in this paper is the IMPACT3, which is the latest updated in 2015. It consists of 159 countries, 154 basins, and 62 agricultural commodities markets. The model contains a global model, regional and national sub-models. In the model, the international agricultural commodity equilibrium prices are computing yearly. In each national or regional sub-model, supply, demand, and prices for agricultural commodities are determining. Country and regional agricultural sub-models are linking through trade (Calzadilla, & al, 2009). The structure of the IMPACT model is presenting in figure 3. It contains a climate model, a water model, a crop model, and a macroeconomic model. The Earth System Model (ESMs) is used to deliver climate data as inputs to the water and crop simulation models (Robinson, et al., 2015). The full description of the multimarket IMPACT model can be found in (Robinson, et al., 2015).

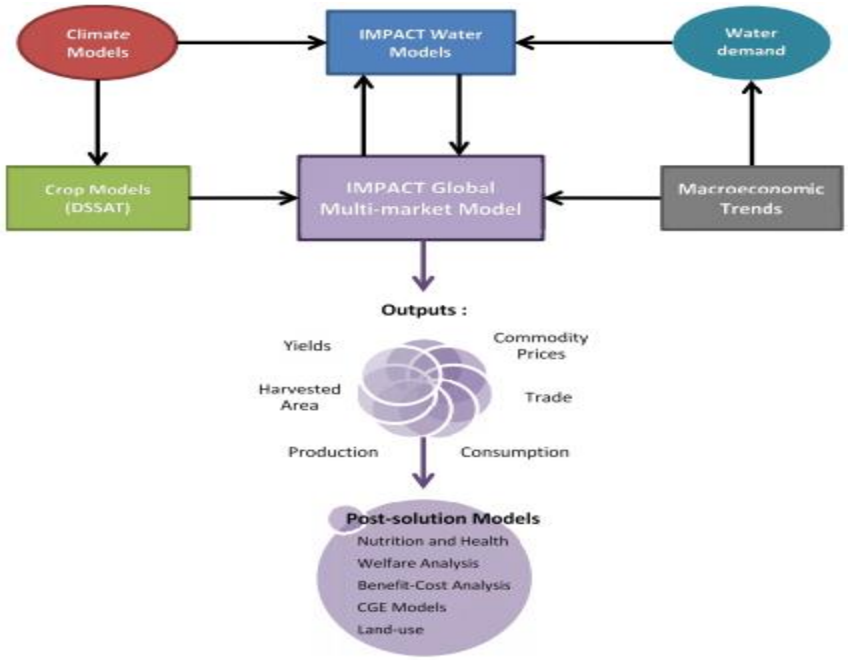

Figure 3:IMPACT model

Source : (Robinson, et al., 2015)

3.2.GTAP standard model and database

The Global Trade Analysis Project (GTAP) standard model is a static General Equilibrium Model covering the whole world and assuming perfect competition, constant returns to scale, and quantity homogeneity in the production sectors. GTAP standard model is derived from the family of neo-classical theory models, which present, on the one hand, real variables, and relative prices, and on the other hand, price level. The model is global because it includes all the world countries, with some countries represented individually and others incorporated in regional aggregates. Countries follow the same pattern of representations with some differences in the data reference years. The model is compatible with the input-output data framework, and all the supply and uses of the different goods are included. The GTAP model resolution requires a non-linear solution methodology since its formulation is non-linear.

In this paper, we use the GTAP Africa 2 database. GTAP data is a global database describing the world economy in a reference year. It includes input-output tables for different countries or regions, data on bilateral trade, taxes, and transport margins. The data are compatible with many CGE models used for policy analysis.

The GTAP Africa 2 data were released with GTAP 8 data. These data include 42 regions/countries in which 32 are African countries and 57 activity sectors. Burkina Faso is added as a single region in the data. The input-output tables of Burkina Faso for aggregating the GTAP data were supplied by Balma (2012). The data contain the Social Accounting Matrice of Burkina Faso in the year 2005. This SAM has 132 accounts of goods and services and 74 accounts of converted activities into the GTAP standard input-output table style. To fulfill this study's objectives, we aggregate the GTAP Africa 2 into 11 regions, ten sectors, and five production factors, as shown in the annex.

3.3. Welfare decomposition

CGE models offer many possibilities to analyze the welfare effect and the sources of variation following a shock. In the GTAP standard model, the regional welfare is measured as the variations in the regional household utility or equivalent variation. The equivalent variation is a money-metric indicator that quantifies the change in the household's utility. Therefore, we can compute a shift in regional welfare by computing the difference between the utility level at the base scenario and the utility level after introducing a shock in the model.

The welfare decomposition technique consists of determining welfare change sources following a shock or a policy change. The welfare change can be decomposed into allocative efficiency, trade terms, technology efficiency, endowment change, and population effect. Hertel & Huff, (2000) develop a methodology associated with the GTAP standard model to decompose the welfare variation into its different variation sources. For instance, the allocative efficiency effect on welfare results from the economic resources' reallocation caused by economic distortions. The terms of trade' effect on welfare change arise from a shock's impacts on exports and imports prices of a region. The variation of economic factors stocks causes the factors or endowment effect on welfare change following a shock or policy change. For example, an increase in capital stock will increase regional welfare. Finally, the change in the population influences regional welfare.

4. Scenarios description

In analyzing the effect of climate change, we define two scenarios that represent different perspectives of the economic situation of Burkina Faso and the world economy. A scenario without climate change is named baseline scenario, and four climate change scenarios.

The baseline scenario depicts the socioeconomic indicators' trend from 2005 to 2050, assuming a stable climate. Therefore, Shared Socioeconomic Pathway assuming a stable climate from 2005 (SSP2-NoCC) projections were used. Shared Socioeconomic Pathways display different possible changes in the global economy, society, and demography in the future. The SSP2, called the 'middle of the road' scenario, depicts a future world where global indicators will not significantly differ from their historical trends. In fact, in this scenario, economic growth and environmental degradation will keep their current increasing trend but slower in the future. Using the SSP2 scenario's projections estimated with the IMPACT model, we describe the socio-economic indicators such as population, real GDP, labor force, and cropland trends in 2005-2050.

The results of the baseline scenario are comparing to four climate change scenarios. In general, climate change impacts are estimated using the Global Climate Models (GCM) and biophysical models. Firstly, Global Climate Models (GCM) are used to simulate the physical climate change effect. Secondly, biophysical models are employed to translate these physical effects into economic shocks. However, the challenge is that different GCMs produce distinct projections of climate change effects. According to Dudu (2013), each GCM prediction is a probability distribution sample, which can be defined by a mean and a standard deviation. Therefore, using many climate scenarios is likely to give better results. In this study, we define four climate change scenarios according to different GCMs. The four GCMs include the Earth System Model of the Geophysical Fluid Dynamics Laboratory (GFDL), the Hadley Centre of Global Environment Model (HADGEM), the

Institute Pierre Simon Laplace Model (IPSL-CM5A), and the Model for Interdisciplinary Research on Climate (MIROC). Using these climate change scenarios, we estimate climate change agriculture shocks (yields and arable lands changes). These agriculture shocks are then included in the GTAP model to analyze the climate change welfare impacts. The different Scenarios are summarizing in table 3.

Table 3: Scenario's description

Scenarios	**Description**
SSP2_NoCC	It supposes an economic trend with a constant climate
SSP2_MIROC	Climate change scenario estimated under MICROC GCM
SSP2_IPSL	Climate change scenario estimated under GCM IPSL
SSP2_GFDL	Climate change scenario estimated under GCM GFDL
SSP2_HADGEM2	Climate change scenario estimated under GCM HADGEM

Source: Author

4.1.Baseline scenario experiment

The baseline scenario explains the socio-economic indicators during 2005-2050, assuming a stable climate. Therefore, to develop this scenario, we use projections throughout 2050 for GDP, population, arable land, capital stock, and labor. Population, GDP growth, and arable land are obtained with the IMPACT model, and capital stock and labor growth rates are taking from (Foure et al. 2012). In the baseline scenario, most of these variables have an increasing trend during 2005-2050 in all the regions. In Burkina Faso, the population will increase by 171.8% in 2050 (figure 4). This high population growth rate is explained by the country's annual population growth rate, estimated at 3%. The GDP will increase by more than 1000% and precisely by 1442.21% in 2050 relatively to its level in 2005. Also, production factors will increase respectively, with a rate of 50.63 %, 267.80 %, and 1122.28% for land, labor, and capital stock. In the GTAP model, GDP is an endogenous variable, and to impose the projected value of GDP, we need first to interchange GDP for total factor productivity and solve for the total factor productivity, which corresponds to projected GDP (Burfisher, 2011). After solving this total productivity, we restore the model with GDP endogenous and productivity exogenous.

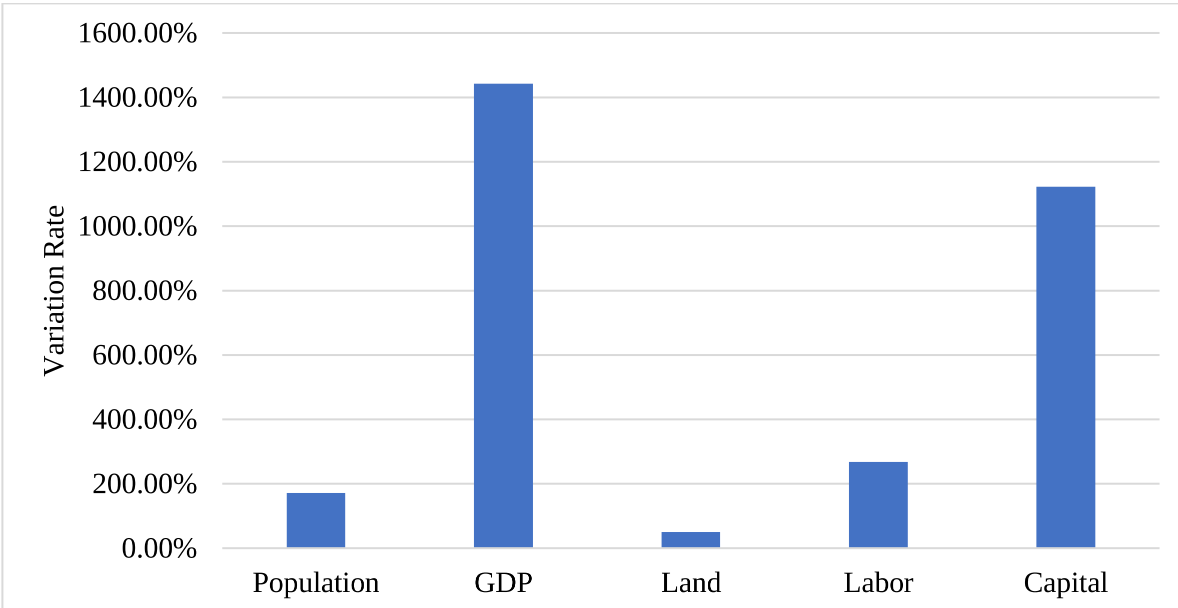

Figure 4: *Socioeconomic indicator in the baseline scenario in %*

Source: *Made by the author using Foure et al. (2012) and IFPRI data*

4.2.Climate change scenarios experiment

4.2.1. Effect of climate change on agricultural yield

Figure 5 displays climate change's effects on agriculture production yields according to different scenarios. It shows that the four climate scenarios will lead to a drop in the average agriculture yield in Burkina Faso in the 2005-2050 period. The SSP2-IPSL predicts the highest decline rate estimated at -22.94%, while the lowest decreasing rate estimated at -2.47% occurs in the SSP2-MIROC scenario. The decrease of average crop yield is also observed in most other regions and the four scenarios, except in Oceania and East Asia, where an increasing rate is observed in some scenarios. However, the extent of yield shift is highly fluctuating according to region and scenario. The most considerable change in yield estimated as –32.20% is observing in North America under the SSP2-GDFL climate change scenario.

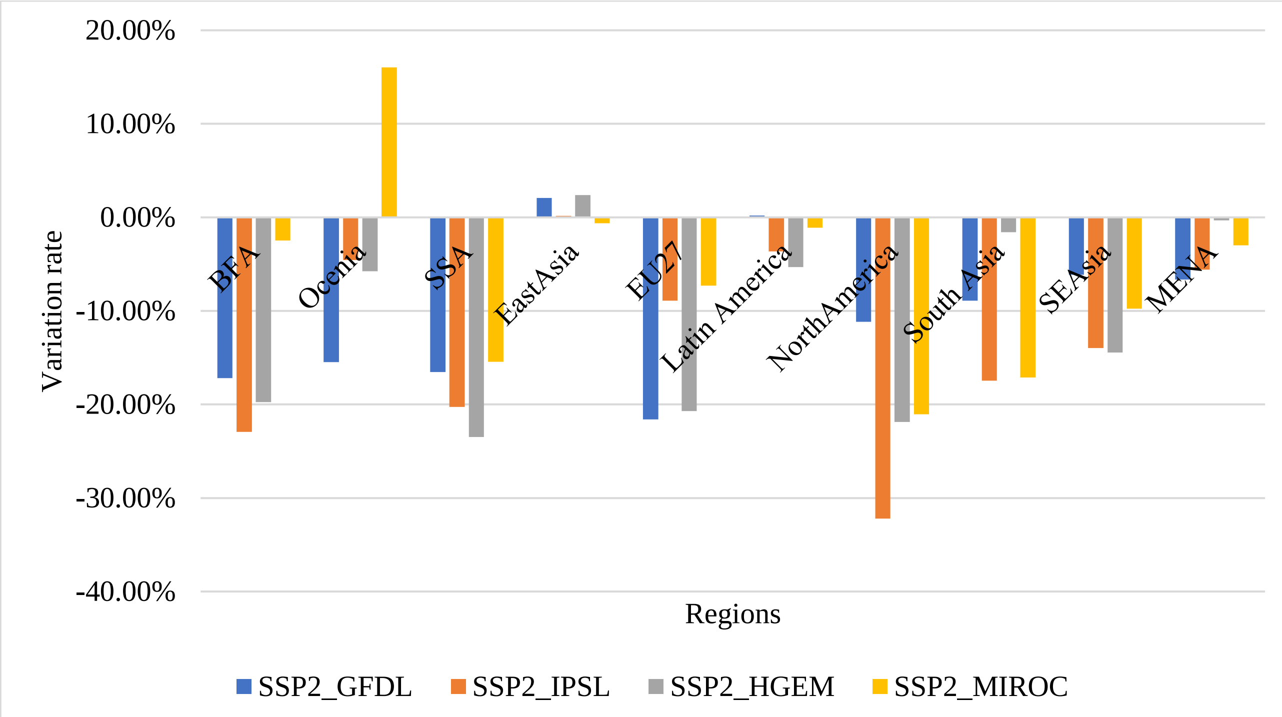

Figure 5*: Effect of climate change on yield during 2005-2050*

Source: *Simulations using GTAP standard model*

4.2.2. Effect of climate change on arable lands

Figure 6 displays the effect of climate change on croplands. It shows that climate change will increase harvested croplands in Burkina Faso. The highest increase will be in the SSP2-MIROC scenario, while SSP2-GFDL gives the lowest increasing rate of croplands due to climate change in Burkina Faso. Climate change will also increase lands used in the other regions, with the most massive increase observed in the MENA region. However, in Oceania, climate change drives a decline in croplands in three scenarios. Besides, different climate change scenarios entrain different variation rates of croplands in different regions. The climate change effects on crop yields and croplands variation will be included in the GTAP model to analyze climate change's effect on welfare.

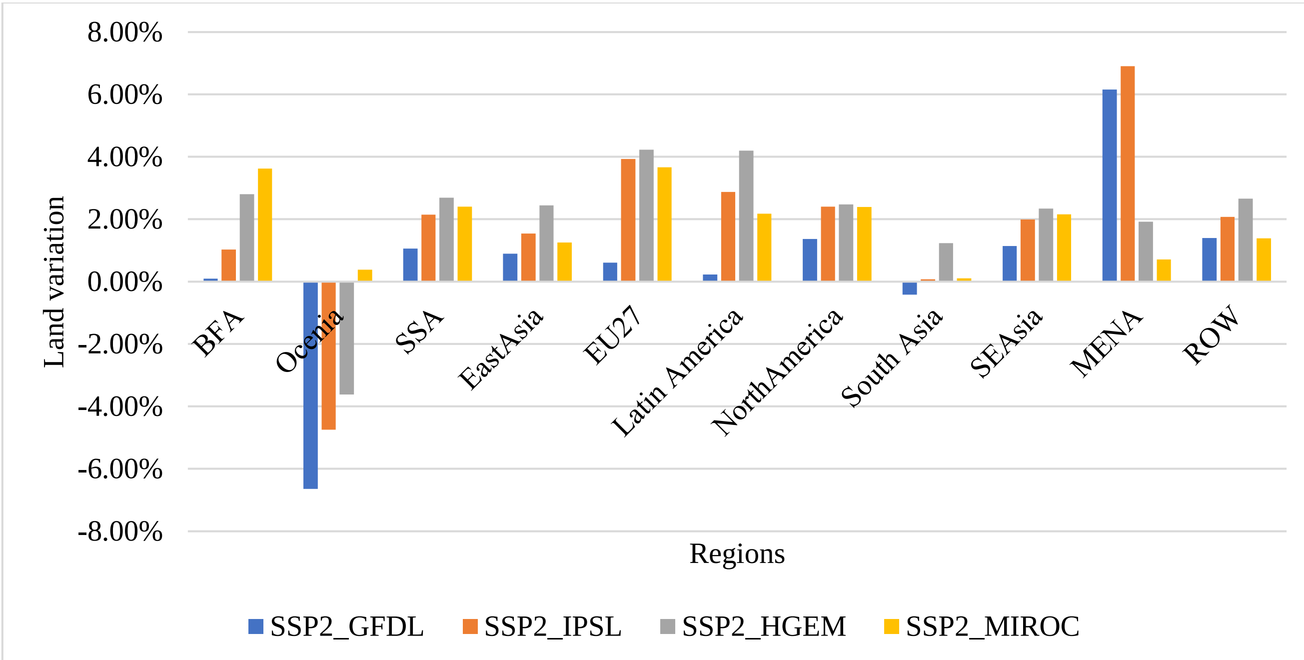

Figure 6: *Effect of climate change on arable land during 2005-2050*

Source: *IMPACT model outcomes*

5. Simulations outcomes

This section presents the simulation results on the effect of climate change on households' welfare in Burkina Faso. We present, respectively, the impact of climate change on real GDP, incomes and expenditure, and regional households' welfare.

5.1 Effect of climate on GDP

The results show that climate change will lead to a loss of GDP in all the regions by 2050, as showing in Figure 7. Indeed, the median effect of climate change is negative in all countries. The extent of the losses is, however, variable among scenarios and regions. Burkina Faso and Sub-Saharan Africa will be the most affected regions, as displayed in Figure 7. In Burkina Faso, the smallest drop in GDP is estimated by the SSP2-MIROC scenario with a GDP decreasing rate estimated at 9.33%, while the SSP2-IPSL scenario forecasts the most considerable decline rate, valued at 17.39%. In other regions, Oceania and MENA regions will be less affected in their GDP by climate change. However, while the scenarios predict different levels of GDP loss, the forecasted signs are the same in all the regions. Therefore, we can conclude that the climate change shocks will lead to a decrease in the real GDP in most of the regions.

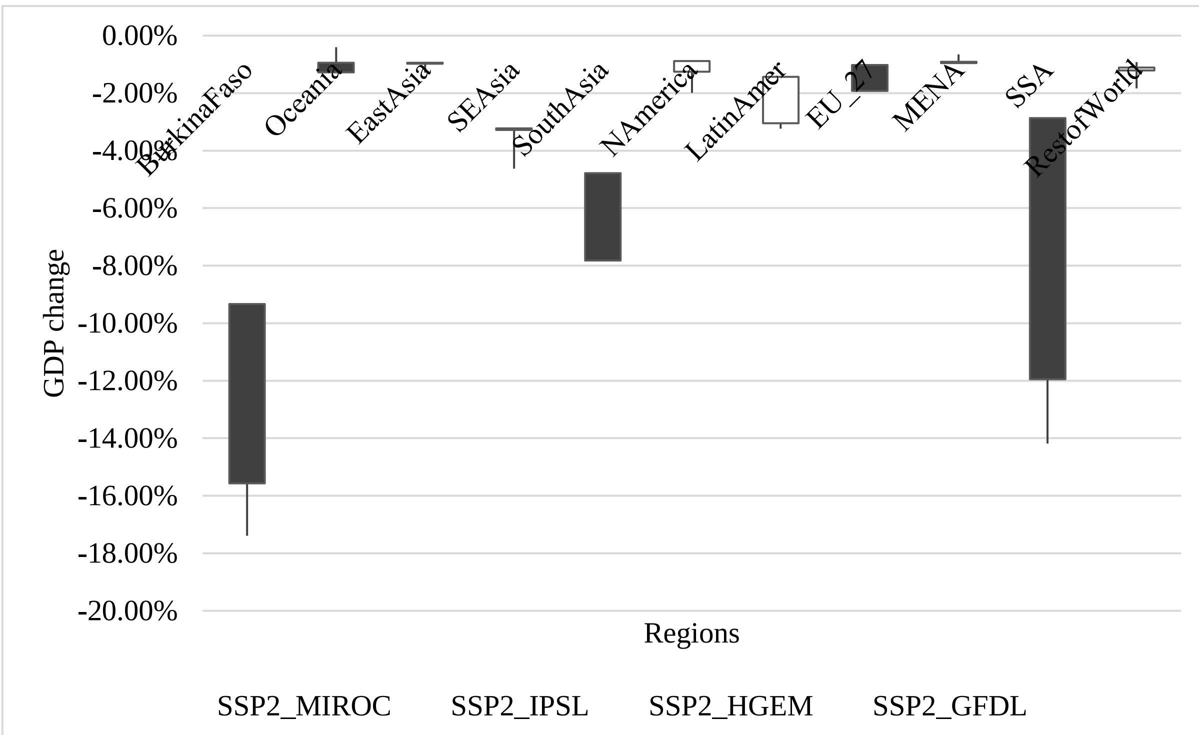

Figure 7: *Effect of climate change on GDP 2005-2050*

Source: *Simulations using GTAP standard model*

5.2. Impact of climate change households demand for agricultural products

The variation in crop productivity and cropland caused by climate change will impact households' demand for agricultural products. Figure 8 presents the variation in the households' demands for agricultural products in Burkina Faso for four climate change scenarios. On average, climate change will decline households' demand for agricultural products by a rate of 21.04% in Burkina Faso. This drop is greater than the decrease observed in the level of GDP obtained in the previous section. The four scenarios' results do not vary very much, and the standard variation coefficient is estimated at 4%. In the other regions, the change in the demand for agriculture products by households due to climate change is negative. As in GDP, Burkina Faso and the other Sub-Saharan countries make the most critical losses in terms of agricultural products demand, as shown in Figure 9. Oceania and North America will be the regions with the lowest losses. These negative effects of climate change on households' consumption will negatively affect their global welfare.

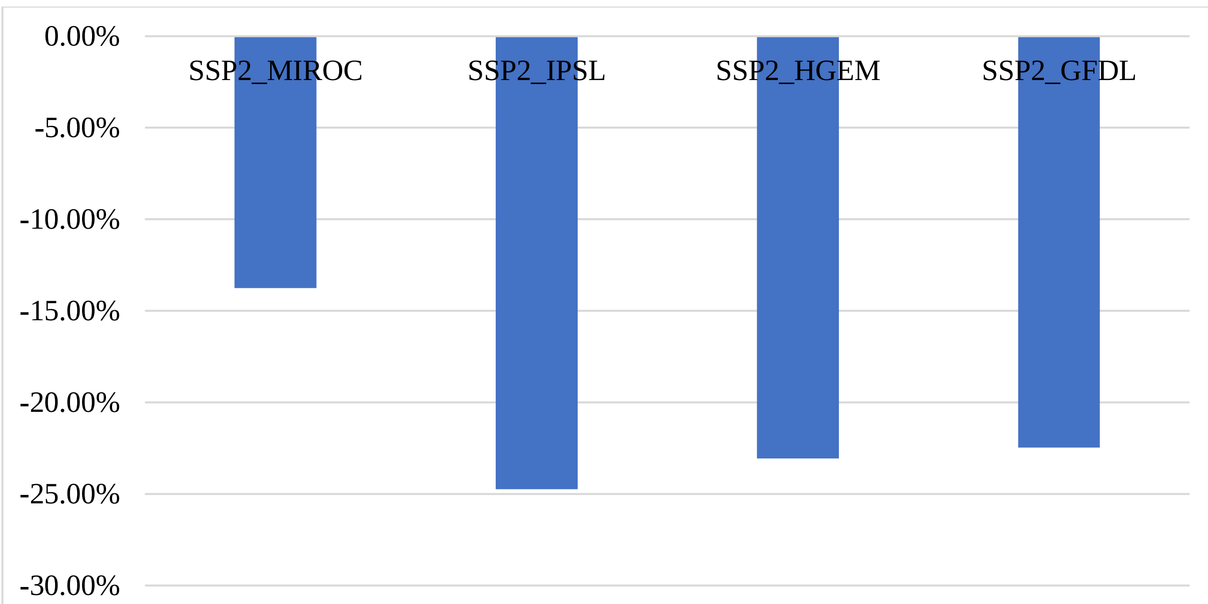

Figure 8:*Effect of climate change on household's agricultural products demand in Burkina Faso 2005-2050*

Source: *Simulations using GTAP standard model*

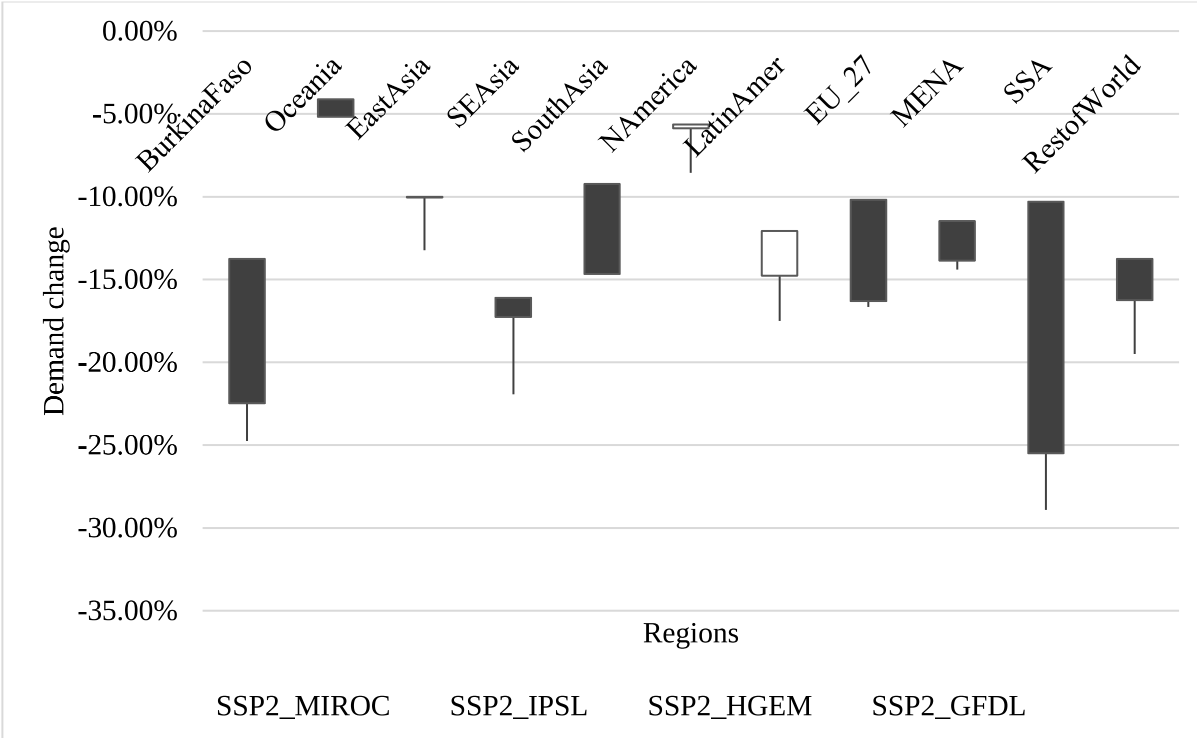

Figure 9*: Effect of climate change on household's agricultural products demand*

Source: *Simulations using GTAP standard model*

5.3. Impact of climate change on global welfare

5.3.1. Variation of the Equivalence Variation (EV)

In previous sections, we have shown that climate change agriculture impacts will lead to a decline in GDP and households' agricultural products consumption. These negative impacts will likely affect the overall household' welfare in these regions. In fact, in countries like Burkina Faso, where the agricultural sector constitutes the main income source, a drop in agriculture production will significantly affect the household's welfare. The change in agriculture production will increase agricultural products' prices and therefore decrease their incomes. Subsequently, this reduction in incomes will decrease the demand for goods and services. Figure 10 presents the shift in households' welfare measured by the EV in Burkina Faso. The four scenarios indicate that climate change will negatively affect regional households' welfare. The average welfare loss predicted is estimated at a 14% decline of global welfare relative to the baseline scenario. The minimum loss, evaluated to 8%, is given by the SSP2-MIROC scenario, while the SSP2-IPSL predicts the highest decline in households' global welfare. In the other regions, the changes in EV are displaying in Figure 11. From this figure, we can see that the extent of climate change's effect on welfare varies highly across regions. African regions are the most affected, while Europe is less concerned and will benefit from climate change in the SSP2-IPSL scenario. In terms of scenarios, the predicted changes in welfare are very heterogeneous. For instance, while in Burkina Faso, SSP2-IPSL is the scenario with the highest loss, in Subsaharan Africa, SSP2-HGEM is the one simulating the most significant welfare variation.

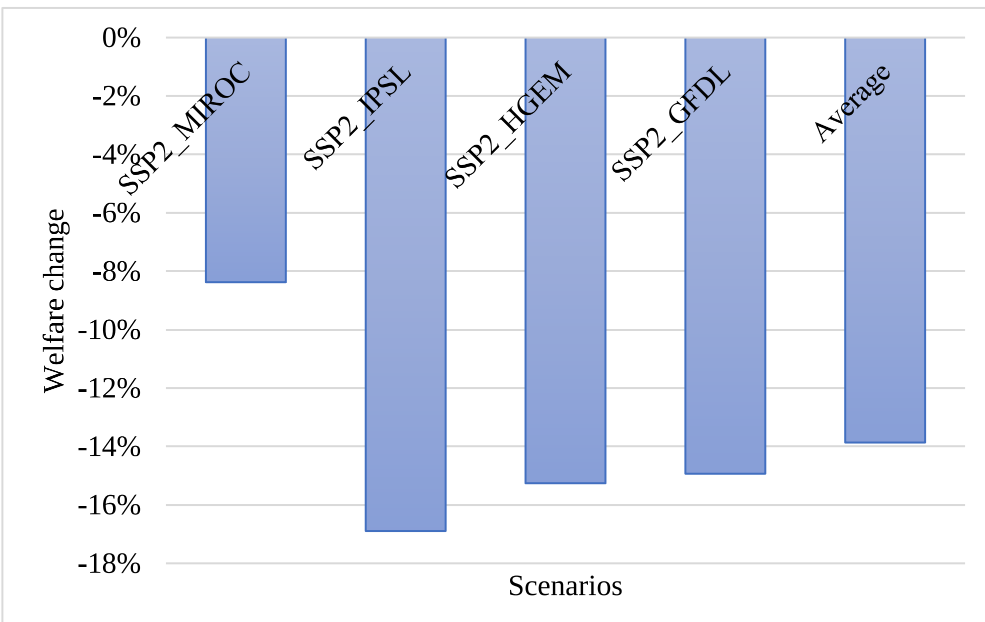

Figure 10: *Effect of change in welfare in climate change scenarios in Burkina Faso 2005-2050*

Source: *Simulations using GTAP standard model*

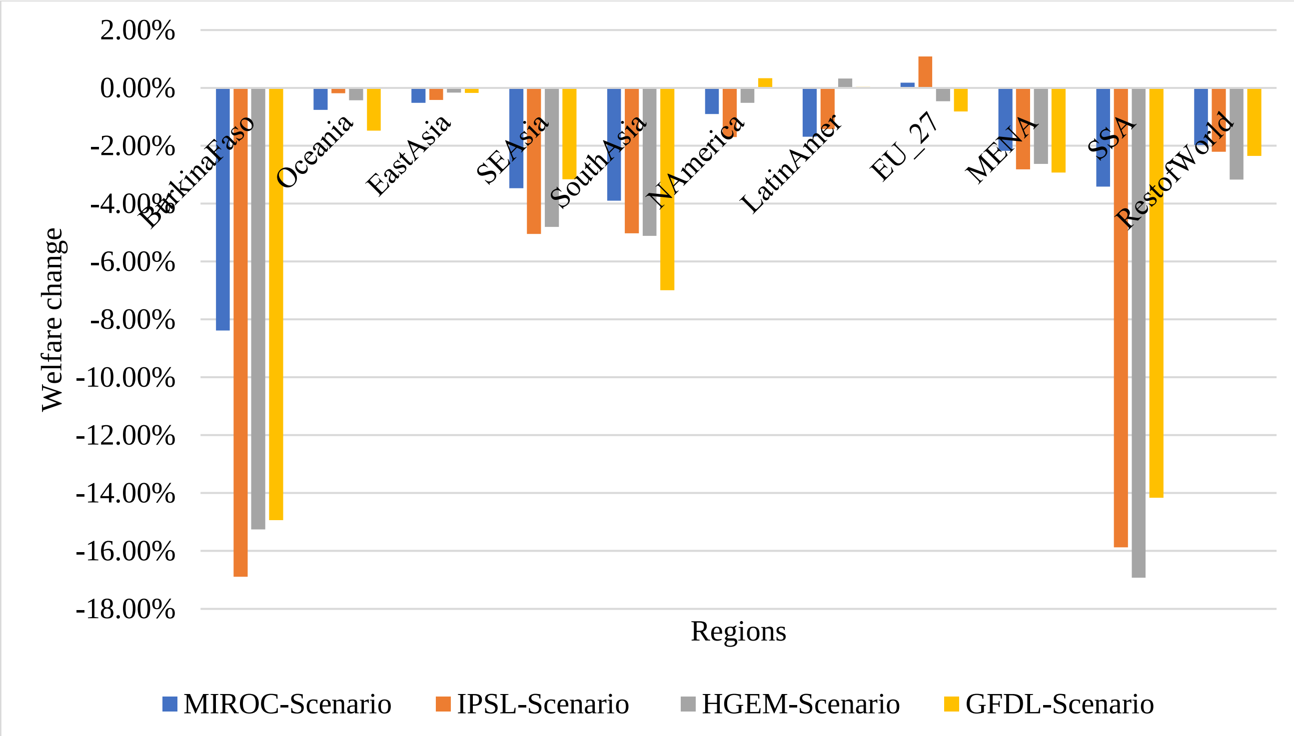

Figure 11: *Effect of change in EV in climate change scenarios in different regions 2005-2050*

Source: *GTAP standard model simulation outcomes*

5.3.2. Welfare decomposition.

The welfare decomposition aims to explain the source of welfare change induced by the climate change shocks. These welfare variation sources include allocative efficiency, factors endowment, technology change, Population, terms of trade, and investment/savings. Figure 12 displays the contribution of each factor to welfare variation in the different climate scenarios. This figure shows that only investment and saving contribute positively to welfare change under climate change scenarios. However, this positive contribution is small on average compared to the other negative contributors. On the other hand, it is indicated that in Burkina Faso, the two major welfare change drivers are capital endowment and technology efficiency in the four climate change scenarios. Each of these sources contributes negatively to more than 30% of welfare change due to climate change. This result is explained by the fact that climate shock introduces a negative technology shock in the agriculture sector and leads to a decline in the economy's production factors. The other welfare loss sources in Burkina Faso are population effects, allocative effect, and terms of trade effect.

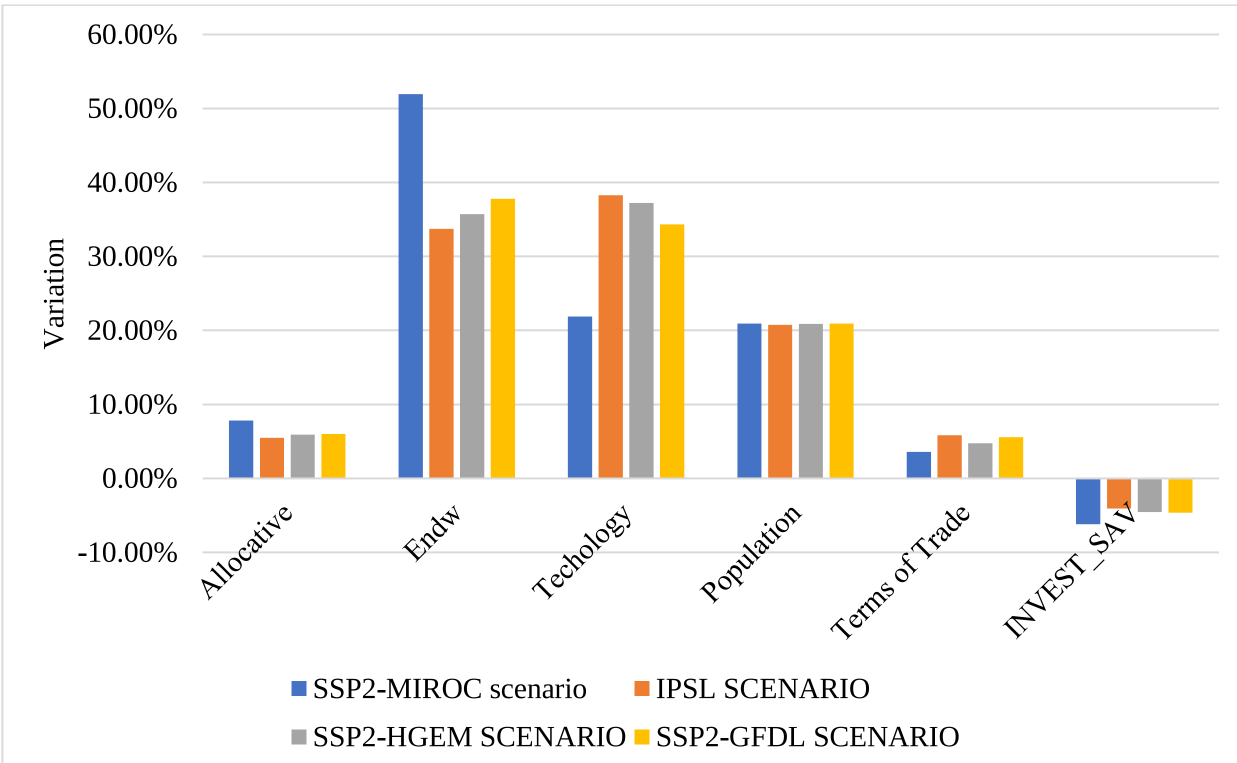

Figure 10: *Welfare decomposition in Burkina Faso for different climate scenarios*

Source: *GTAP standard model simulation outcomes*

Conclusion

This paper analyzes climate change's impacts on households' welfare in Burkina Faso using the GTAP model. The simulation outcomes show that climate changes will negatively impact global household welfare in Burkina Faso. For instance, the results show that climate change will result in a loss in regional GDP, a decline in households' demand for agricultural products, and global welfare. The results also indicate that Sub-Saharan African regions will be the most affected in terms of welfare loss. On average global warming will cause a loss estimated to 14% of regional households' welfare in Burkina Faso. To our knowledge, it is the first time that a study precisely quantifies the climate change effect on households' welfare in Burkina Faso. The findings present some similarities with previous studies done on the African continent. They are in line with (Zidouemba's (2017)) findings of climate change impacts on Burkina Faso.

On the other hand, the results distinguish from some SSA studies. Dudu's (2013) study shows that climate change will increase welfare in SSA, while our study finds the opposite results. These differences in the results are probably due to the many uncertainties in climate variables data prediction in Africa.

This paper makes an essential contribution by estimating the magnitude of climate shocks' impact on household welfare by proposing a novel methodology to link the IMPACT model-generated shocks to the GTAP model.

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Annexes

a. Region’s aggregation

Region	Description
BFA	Burkina Faso
SSA	Sub-Saharan Africa
Oceania	Australia, New Zealand
EastAsia	East Asia
SEAsia	Southeast Asia
SouthAsia	South Asia
NAmerica	North America
LatinAmer	Latin America
EU_27	European Union 25
MENA	Middle East and North Africa
RestofWorld	Rest of World

b. Sectors’ aggregation

Sector Code	Description
GrainsCrops	Grains and Crops
MeatLstk	Livestock and Meat Products
Extraction	Mining and Extraction
ProcFood	Processed Food
TextWapp	Textiles and Clothing
LightMnfc	Light Manufacturing
HeavyMnfc	Heavy Manufacturing
Util_Cons	Utilities and Construction
TransComm	Transport and Communication
OthServices	Other Services

c. Factors’ aggregation

Factor code	Comprising	Mobility
Land	Land	Nonmobile
NatRes	NatRes	Non-mobile
Capital	Capital	Mobile
Labor	UnSkLab, SkLab	Mobile

Source: GTAP Africa 2 data aggregated by author