pep partnership for economic policy

The economic impact of climate change in Burkina Faso from a gender perspective.

Authors Boureima SAWADOGO | Ismael FOFANA

Date July 2021

Working Paper 2021-04

PEP Working Paper Series

ISSN 2709-7331

The economic impact of climate change in Burkina Faso from a gender perspective

Abstract

Burkina Faso faces significant challenges in terms of gender inequality, especially regarding employment and economic opportunities. Agriculture, the main provider of employment, is threatened by climate change. Our study contributes to the understanding of the gender distributive effects induced by climate change. The climate shock is introduced stochastically to accommodate the uncertainties related to the evolution of the climate and its effects on agricultural yields. An economywide framework is used to capture the backward and forward linkages of the agricultural sector to the non-agricultural sectors. Our results show that in average, climate change is slightly unfavorable towards women's economic activities compared to men's. However, the high level of uncertainty surrounding the impact of climate change on agricultural yields makes it difficult to find significant gender bias in the distribution of economic effects of climate change in Burkina Faso.

JEL Classification : Q54, Q18, J16, C68, O55

Keywords: Climate change, Agriculture, Gender, Economywide modelling, Burkina Faso

Authors

Boureima SAWADOGO
Economist
University Thomas Sankara (UTS)
Ouagadougou, Burkina Faso
tboureima94@yahoo.fr

Ismael FOFANA
Director,
Capacity and Deployment AKADEMIYA2063
Kigali, Rwanda
ifofana@akademiya2063.org

Acknowledgements

This study has benefited from technical and financial assistance from the Partnership for Economic Policy (PEP) (www.pep-net.org), funded by the Government of Canada through the International Development Research Centre (IDRC). The authors are grateful for the technical support and advice given by ZONG-NABA Aminata, TIENDREBEOGO M. Nadège, OUEDRAOGO Agnès, NIKIEMA Adama, BAZIE Izompin Sarra B. and Mariam Diallo, and for the valuable comments and suggestions made by Helene Maisonnave.

Table of contents

I. Introduction 1
II. Climate change and gender inequalities in Burkina Faso 5
III. Methodology and data 8
IV. Scenarios and results 13
4.1. Impact of climate change 14
4.2. Adaptation strategy to climatic conditions 17
V. Conclusion 19
References 20
Appendix 27

List of tables

Table 1: Change in agricultural yields (in percentage) 13
Table 2 : Percentage Changes in Value Added in the Agricultural Sector 15
Table 3: Percentage Changes in Value Added in the Non-Agricultural Sectors 16
Table 4 : Percentage Changes in Male and Female Value Addition 17
Table 5: Percentage Changes in Agricultural and Non-Agricultural Value Added Under Different Scenarios of Female Economic Migration 18
Table 6: Percentage Changes in Male and Female Value Added Under Different Scenarios of Female Economic Migration. 18

Table A. 1 : Distributional share of value added by gender (in percentage) 27

I. Introduction

Climate change is happening, and its negative effects can be felt around the world. Climate change is having a long-term impact on temperature, the intensity and spatial distribution of precipitation, and on the frequency of the occurrence of droughts and floods (IPCC, 2007). Although it is a global phenomenon, its effects vary from one country to another, and from one group of individuals to another. It is worth noting that its consequences are potentially more significant for developing countries and poorer populations (IPCC, 2007). Previous studies show that the most vulnerable societies to climate change are those that lack the resources to prepare and adapt (Campbell-lendrum & Corvala, 2007; IPCC, 2014a).

The question of the gender neutrality of climate change is fuelling political and scientific debates. Recent literature shows that women are more affected by climate change (Adzawla et al., 2019; Andersen et al., 2016; Eastin, 2018; Paudyal et al., 2019; Rao et al., 2019). Rural women are among the most vulnerable groups (Chindarkar, 2012) because they are more involved in climate-sensitive activities and have limited access to productive assets and markets (Buechler, 2009). The agricultural sector is an important source of employment for women in developing countries. On average, women account for 43% of the agricultural labour force in developing countries (FAO, 2011a).

Despite their important contribution to the agricultural sector, women have less access than men to productive resources (assets, inputs, services, land, education, financial services, technologies) and to economic opportunities (World Bank, 2015; FAO, 2011a). Compared to men, women are more involved in seasonal activities and receive lower wages (FAO, 2011b). In addition to agricultural activities, women are also occupied with domestic activities, such as caring for the children and other family members and fetching firewood and water. Thus, the effects of climate change could further worsen these existing gender economic inequalities.

The most important channels through which climate change affects people's well-being are agriculture, health and labour productivity (Letta, Montalbano, & Tol, 2018). The agricultural sector is widely recognized as the most vulnerable sector to climate variability in developing countries (Knox et *al*., 2008; Philip K Thornton, Ericksen, Herrero, & Challinor, 2014; Wollenberg et al., 2012). In these countries, agriculture is an important driver of economic growth and is a key sector for the creation of employment and income, and therefore for the reduction of poverty and ensuring food security (FAO, 2011a). The risks to livelihoods from climate shocks include reduced crop yields, reduced availability of water and pasture, loss of livestock and destruction of other productive assets (Campbell-lendrum & Corvala, 2007; FAO, 2008; IPCC, 2001, 2014b; Muller, Cramer, Hare, & Lotze-Campen, 2011). Thus, countries that are already suffering from water stress or scarcity are likely to experience further declines in agricultural yields, which may have implications for rural household incomes and food security (Breisinger, Ringler, Aragon, Aragon, & Ecker, 2010).

Climate change-induced land degradation and reduced access to natural resources (land and water) are also leading to the displacement of civilians. (Chindarkar, 2012). This is due to frequent droughts, changing rainfall patterns and floods that result in reduced smallholder and subsistence farming production. Weather anomalies have direct and significant impacts on agricultural activities, but manufacturing activities are less directly impacted.

Since agricultural activities are essentially rural and manufacturing activities primarily urban, the movement of people is generally from rural to urban areas (Marchiori, Maystadt, & Schumacher, 2012). Moreover, the effects of climate change on the movement of people are likely to have a disproportionately negative impact on vulnerable and poorer population groups, in particular women (Hunter & David, 2009). With the increasing negative impacts of climate change, it is becoming increasingly difficult to provide economic opportunities for rural women and men. Consequently, migration becomes an important means of coping with climate shocks. However, women have a lower tendency to migrate than men (Balikoowa, Nabanoga, Tumusiime, Mbogga, & Balikoowa, 2019) because of their status and social norms.

In order to find appropriate measures to prevent or minimise the adverse impacts of climate change, especially on vulnerable groups, it is necessary to understand its socio-economic impacts. This is why this issue is of interest to policy makers and scientists. Our study contributes to the understanding of these impacts in Africa. It evaluates the effects of climate change on economic inequalities from a gender perspective in Burkina Faso.

Although there is a large body of literature concerning the impact of climate change in developing countries, little is known about the distributional impacts of climate change between population groups, particularly between men and women, in Africa. Burkina Faso is an interesting case study for several reasons. Lying in the transition zone between the Sahara desert to the north and the tropical forests to the south, the country is prone to extreme weather events such as recurrent droughts, floods and windstorms (World Bank, 2013b). The country ranks 147 out of 162 countries in terms of gender inequality, with the largest gender disparities found in education and employment (UNDP, 2018).

The agricultural sector is the driving force behind the economy and accounts for 35.3% of gross domestic product (GDP) and employs 73.3% of women and 67.7% of men (OCDE, 2018). Subsistence, rain-fed and extensive agriculture are particularly vulnerable to climate change (Herrera & Ilboudo, 2012). There is a risk that climate change will have devastating consequences for the agricultural sector. Given that a significant proportion of the population is reliant on this activity, a climate shock to the agricultural sector may have huge consequences for the whole economy.

In addition to the industries processing and distributing agricultural products, many other sectors of the economy are likely to be indirectly affected through impacts on income and consumption. Since climate shocks can affect several sectors of the economy directly and indirectly, the interactions between the different sectors need to be understood, to assess the full economic impacts of climate change in the agricultural sector. In this regard, Computable General Equilibrium (CGE) models are suited to capture these interactions between the agricultural sector and the rest of the economy.

CGE models have been used to assess the impact of climate change in developing countries (e.g. Arndt, Robinson, & Willenbockel, 2011; Arndt, Schlosser, & Strzepek, 2015; Calzadilla, Zhu, Rehdanz, Tol, & Ringler, 2013; Montaud, 2019; Montaud, Pecastaing, & Tankari, 2017)). Two methods are used in the literature to integrate the climate shock into the CGE models. These include deterministic approaches (e.g. Bosello, Campagnolo, Cervigni, & Eboli, 2017; Calzadilla et al., 2013; Gebreegziabher, Zenebe; Jesper, Stage; Alemu, Mekonnen; Atlaw, 2015) and stochastic approaches (by Arndt, Robinson, et *al*., 2011; Arndt et *al*., 2015; Arndt & Thurlow, 2015; Thurlow, Dorosh, & Yu, 2012).

Unlike deterministic scenarios that use average changes in crop yields as shocks, stochastic scenarios include the uncertainties associated with climate variability. Previous work has focused on the effects of climate change on agricultural and non-agricultural production, as well as employment trends and income distribution. To our knowledge, some studies have focused on the gender impact of climate change (Arndt & Tarp, 2000; Escalante & Maisonnave, 2020b) although these studies have not implemented stochastic shocks to capture uncertainties associated with climate variability. To date, no study employing the general equilibrium approach has yet evaluated the gender-specific economic impact of climate change in Burkina Faso.

Based on the current knowledge of the effects of climate change on agricultural yields in West Africa, we evaluate its economic implications for both men and women in Burkina Faso. The climate shock is translated into changes in the productivity of agricultural activities and, consequently, spreads through the economy via the sector's backward and forward linkages with the rest of the economy. Our study uses a CGE modelling framework to capture this interrelationship between the agricultural and non-agricultural sectors. The climate shock is introduced using the stochastic approach to capture the uncertainties surrounding climate change in Burkina Faso and its effects on agricultural yields.

The rest of the paper is structured as follows. The issue of climate change and gender is put into context in section 2. A review of the methodological approaches and the model and data used in this study are presented in Section 3. In section 4, the simulated scenarios are presented and the findings discussed. Finally, in Section 5, the main findings of the study are summarised.

II. Climate change and gender inequalities in Burkina Faso

Burkina Faso is located in the transition zone between the Sahara desert to the north and the coastal rainforests to the south. The country is prone to extreme weather events such as recurrent droughts, floods and windstorms (World Bank, 2013a). There is considerable variation in rainfall in the country, ranging from an annual average of 350 mm in the north to more than 1,000 mm in the southwest. Since the 1970s, the country has experienced recurrent droughts. Indeed, between the years 1991 and 2009, the country has experienced three major droughts (1990-1991, 1995-1996 and 1997-1998), impacting over 96,000 people (Crawford et *al.*, 2016). The studies on climate change show that Burkina Faso will experience an average temperature increase of 0.8°C by 2025 and by 1.7°C by 2050 and that rainfall will decrease by 3.4% by 2025 and by 7.3% by year 2050 (Ministry of the Environment and the Living Environment, 2007). Reduced rainfall and rising temperatures would mean long periods of drought and flooding.

Burkina Faso is experiencing a high population growth rate of 3.1% per year (National Institute of Statistics and Demography, 2017). The population which is estimated to be 19.7 million inhabitants in 2019 is made up of 49.9% men and 50.1% women (World Bank, 2019). Despite the climatic disruptions, Burkina Faso's economy has grown strongly over the past decade, with an average annual growth rate of over 6.0% between the years 2000 to 2012 (FAO, 2014). Nevertheless, wealth creation is unevenly distributed between men and women. The gross national income per capita is 1,336 CFA francs for women and 2,077 CFA francs for men (UNDP, 2019). This imbalance is strongly linked to the different participation rates of men (75.1%) and women (58.5%) in the labour market (UNDP, 2019).

Gender inequalities are visible in the labour market. The latest national survey on employment and the informal sector in Burkina Faso reveals a low level of unemployment coupled with a high level of underemployment. Thus, unemployment affects 3.0% of men compared to 4.9% of women, while underemployment affects 16.3% of men and 30.3% of women (National Institute of Statistics and Demography, 2016). Unemployment among young people aged 15 to 24 years old is relatively higher and affects young women to a greater extent than young men. Indeed, the unemployment rate for young women aged 15 to 24 years old is 12.9% whereas it is 5.3% for young men (World Bank, 2019). Inequalities in the distribution of jobs leads to disparities in incomes and in the incidence of poverty. The monetary poverty rate of women is higher than the rate for men (43.7% versus 40.6%) (Agbodji, Batana, & Ouedraogo, 2015). Successive reports by the Intergovernmental Panel on Climate Change (IPCC) have shown that environmental degradation and particularly climate change has become a major factor driving the growth of human migration (Brown, 2008; Kaczan & Orgill-Meyer, 2020). These effects of climate change will further worsen existing problems such as poverty, food insecurity, degradation of resources and infectious diseases (IPCC, 2007).

The Burkinabe economy has long been characterised by population mobility. The proportion of the population living in rural areas declined from 84% in 2003 to 78% in 2014 (World Bank, 2016). The decline in the rural population tends to be of greater benefit to the larger cities, especially the capital, whose population increased by 9% in 2003 to 14% in 2014 (World Bank, 2016). Over the past 15 years, rural migration has been driven by a decline in the share of the population living in farm-headed households towards urban households, headed by people working in trade or construction (World Bank, 2016). The percentage of men moving from rural to urban areas is 28%, while rural-urban migration among women is 12% (Cattaneo & Robinson, 2020).

The agricultural sector is the engine of the economy, accounting for 35.3% of gross domestic product (GDP) and employing more than 70.0% of the workforce. Unfortunately, this sector suffers from many disadvantages. In fact, 34.0% of all agricultural land is degraded, with the rate of degradation increasing from 113,000 ha/year between 1983 and 1992 to 360,000 ha/year between the years 1992 and 2000 (*10 Year Action Plan* for the *Promotion* of *Sustainable Consumption* and *Production*, *Burkina Faso*, 2010) to 469,000 ha/year between the years 2002 and 2013 (Burkina Faso, 2018). Agriculture is not very diversified. Cotton is the main cash crop and food-crop production, which represents 55.2% of total production, consists mainly of corn, millet, fonio, rice and sorghum.

Agriculture is essentially subsistence, rain-fed and extensive (Herrera et Ilboudo, 2012). However, the country has an irrigable potential of 233,500 ha, of which 67,000 ha are currently under irrigation. Unfortunately, the share of irrigated production is very low, 15.0%

in 2015 (Burkina Faso, 2018). Furthermore, water resources in Burkina Faso are limited and variable. On average, the country receives approximately 206.9 billion cubic metres of water per annum, distributed into three different streams: 4.16% runoff, 15.66% infiltration and 80.2% evaporation (Integrated Water Resources Management (IWRM), 2001). The groundwater reserve is estimated to be approximately 402 billion cubic metres per year with a loss of approximately 268 billion cubic metres of water per year in the event of severe drought (Integrated Water Resources Management (IWRM), 2001).

Climate change threatens agricultural production systems in terms of quantity and the stability of food supply. The existing literature provides evidence on the impacts of climate change on agricultural yields. However, few studies have been carried out on the impact of climate shocks on the agricultural sector in Burkina Faso. Among these, Waongo et al. (2015) predict an average decline in corn yields by 8% between the years 2011 and 2050 in Burkina Faso; Hidalgo et *al*. (2015) report a decline in cowpea, millet and peanut yields by 25%, 15% and 5% respectively. In addition, we use findings from West African, Sahelian and African studies to identify likely changes in crop yields and livestock and fishery productivity in Burkina Faso as a result of climate change.

Sultan, Defrance, & Iizumi, (2019) estimate a decline in millet yields of between 10% to 20% and sorghum yields of 5% to 15% in West Africa as a result of changing climatic conditions. For the West African region, Thomas & Rosegrant, (2015) estimate a variation in rice yields of between -4.4% and 0.5% and in peanut yields of between -5.8% and 0.3%. According to the literature review carried out by Zougmoré et al., (2016) and the estimation results provided by Thomas & Rosegrant, (2015), climate variability leads to a change in yields for the 2000 to 2050 period, by between -25.4% and 13% for tubers, by between -19.5% and -1.5% for oilseeds and by between -30.0% and -10.0% for fruits in West Africa. Thornton, Steeg, Notenbaert, & Herrero, (2009) estimate the decline in livestock yields to be between 20.0% and 30.0% again in West Africa. Lam, Cheung, Swartz, & Sumaila, (2012) estimate the decline in fish yields in West Africa to be between 8.0% and 25.9% from the years 2000 to 2050.

Faced with this emergency, the government has begun planning adaptive measures, giving high priority to measures related to water resources, agriculture, livestock and forestry.

In accordance with the guidelines and requirements of the United Nations Framework Convention on Climate Change (UNFCCC), the Burkinabe government adopted the National Adaptation Programme of Action (NAPA) to climate change in 2007, revised in 2012. The NAPA is included in the National Policy for Sustainable Development up to 2050 and in various sectoral policies, namely the Sector Policy on Agro-Sylvo-Pastoral Production (PS-PASP, 2018-2027) and the Sectoral Policy on the Environment, Water and Sanitation (PS-EES, 2018-2027). Unfortunately, these policies have not explicitly included in their objectives, the reduction of gender inequalities and the role of women in adapting to climate change.

III. Methodology and data

A substantial body of literature now exists regarding the impact of climate change and adaptation measures in developing countries (Millner and Dietz, 2015; Thornton et al., 2014). The methodologies used to assess this impact can be divided into two categories: the first concerns the partial equilibrium approach and the second the general equilibrium approach.

In the context of Sub-Saharan Africa, there is a growing body of work that assesses the vulnerability and the adaptation possibilities of farmers to climate change (Williams et *al.*, 2018). These studies determine how climate change affects regions, communities, households and livelihoods, and which adaptation options are most appropriate in such circumstances. These studies, although using field data, are carried out in a partial equilibrium context. They focus on agricultural production and do not consider the induced impacts on the rest of the local, regional, or national economy. The second category uses the general equilibrium approach to overcome the major drawback of partial equilibrium analysis. Thus, Computable General Equilibrium (CGE) models are used to include the second order effects of a climate shock.

The analysis of the impacts of climate change on the agricultural sector was carried out using two different approaches in the CGE models: the deterministic approach and the stochastic approach. Several studies address the issue of climate change and its impacts on agriculture through a deterministic approach (e.g. Calzadilla, et *al*., 2013; Gebreegziabher et *al*., 2015). Nevertheless, deterministic shocks do not take into account the uncertainties linked to climate change and the impacts on the agricultural sector. However, a growing number of studies incorporate the impacts of climate variability using stochastic scenarios (Arndt et *al*., 2015; Arndt and Thurlow, 2015; Sassi and Cardaci, 2013).

There have been a limited number of studies dealing with the impacts of climate change and adaptation options for agriculture in Burkina Faso (Henderson et *al*., 2018; Kima et *al*., 2015; Ouedraogo et *al*., 2006; Ouedraogo, 2012; Somé et *al*., 2012; Waongo et *al*., 2015; Zidouemba, 2017). Most of these studies use the partial equilibrium approach. However, Zidouemba (2017) compares the economic benefits of the extension of irrigation compared to agricultural extension programmes in a general equilibrium framework. The paper investigated the variation in annual agricultural yields associated with changes in temperature and rainfall. It considers uniform climate change scenarios for the whole agricultural sector, regardless of the difference in crop sensitivities to the climate shock. The latter is introduced in a deterministic manner despite the high level of uncertainty surrounding the evolution of the climatic factors and their impacts on agricultural yields. Furthermore, the study is silent on the distributional effects of the climate shock, especially between men and women.

To the best of our knowledge, no study using the general equilibrium approach has assessed the economic impact of climate change in Burkina Faso from a gender perspective. Escalante & Maisonnave, (2020) carried out a distributional analysis of the effects of climate change between men and women using a deterministic approach. Our study uses a stochastic approach to assess the distributional impact of climate change between both sexes in Burkina Faso. There seems to be a consensus of opinion that climate change affects men and women differently (Goh, 2012) because of inequalities in access to productive resources[1], markets and economic opportunities, and because of the greater tendency of men to migrate in order to adapt to the adverse impacts.

[1] According to the World Bank (2014), women have unequal access to productive resources such as land, chemical fertilizers, and enhanced seeds.

In the existing literature on gender-based CGE models, two approaches can be identified: the 'gender disaggregation' approach and the 'two-systems' approach. The first approach disaggregates the labour factors, production and household categories according to gender. The second approach integrates, alongside the market economy, a non-market economy (domestic activities taking place within households) in addition to gender disaggregation. The 'gender disaggregation' approach is widely adopted to study the impact of trade policies (Arndt et *al*., 2011; Arndt et *al*., 2006; Arndt et Tarp, 2000; Thurlow, 2006) and fiscal reforms (Escalante, Maisonnave, and Chitiga, 2020). It is criticised for its simplicity, as the rules for the behaviour of various agents in the model remain largely governed by neo-classical principles and do not refer explicitly to unpaid labour (Fontana, 2014).

The 'two-systems' approach attempts to overcome the above limitations by integrating the non-market activities taking place within households (Cockburn et al., 2008; Fontana, 2001, 2002; Fontana et Wood, 2000; Siddiqui, 2009; Zacharias et *al*., 2018). However, this class of models still follows neoclassical principles and does not highlight the direct interactions between market and non-market activities. Arora & Rada, (2020) model intra-household dynamics in two rural provinces of Mozambique using a CGE approach. The main characteristics of their model are the integration of the allocation of labour, resources and transfers within households according to social norms and the identification of leisure as a production commodity. This study contributes to the existing body of literature dealing with the impact of climate shocks in Africa. Even though research exists concerning the impact of climate change on the agricultural sector, there is limited analysis of the distributional effects between men and women. Our methodology follows the "gender disaggregation" approach. Labour and capital factors (value added) are disaggregated according to gender as described in the study by (Souratié, Koinda, Decaluwé, & Samandoulougou, 2019).

In our work, we assume the existence of a multitude of profit-maximising and cost-reducing producers given the production technology and the prices determined by the adjustment between supply and demand in the market. Each industry is represented by a nested production structure with several levels. In order to integrate gender related aspects into our approach, we assume the duality of the Burkinabe economy and especially in the agricultural sector where there are two types of agricultural producers: a female producer, i.e. production carried out on a female owned farm, and a male producer where production is carried out on a male owned farm.

We also assume that there is a difference in the use of technology on male and female farms. Male and female value-added substitute each other imperfectly in the generation of the total value added of the sector. In other words, both male and female labour and capital factors can be engaged in the same economic activity and still have different levels of productivity. Thus, labour and capital are also imperfect substitutes in the generation of male and female value added. The labour factor in male and female value added is a composite, including male and female labour, which are also imperfect substitutes. The total value added and intermediate consumption are combined as a fixed share in total production. The other features of our model are similar to the static version of the standard CGE model (PEP 1-1) developed by Decaluwé et *al*. (2013).

Although our model is based on the PEP1-1 model, it also differs by the introduction of rural-urban migration. We consider the economy of Burkina Faso to be dualistic, with a rural sector dominated by agricultural activities and an urban sector dominated by non-agricultural activities (industry and services). The wage paid in the agricultural sector is assumed to be lower than the wage paid in the non-agricultural sector. Workers (men or women) can move between the rural or agricultural sector and the urban or non-agricultural sector. The labour supply (male and female) in rural and urban areas is exogenous. There is an excess supply of labour, i.e. disguised or hidden unemployment, in both areas. Since the expected wage is lower in rural areas than in urban areas, male and female workers migrate from rural to urban areas until the expected wage rate in rural areas is the same as the expected wage rate in urban areas according to the assumption made by Harris et Todaro (1970).

Thus, the labour supply in urban and rural areas depends on the migration of the labour force from rural to urban areas. The migration rate (or the proportion of the labour force that migrates from rural to urban areas) is determined by the ratio of urban-to-rural value added per capita, which in turn depends on the rate of factor remuneration in both the agricultural and non-agricultural sectors. In our work we assume that in addition to wages driving migration, people also migrate to cities in response to climate shocks, and that they do so with a minimum amount of capital. Therefore, economic migration is determined by the economic opportunities that the urban areas can provide.

We adopt a long-term closure rule to take into account more accurately, the time dimension of the climate change issue. Hence, capital is mobile between economic activities, which represents a long-term situation where the economy has time to adjust. Current public expenditure is fixed; the public budget balance is also fixed in relation to GDP, so that Burkina Faso continues to meet the obligations of the West African Economic and Monetary Union (WAEMU). Thus, the introduction of a compensatory mechanism (tax/subsidy) on household income (and consequently welfare) makes it possible to capture the effects of the variation in Government income, following the climate shock. Burkina Faso is a small country in terms of its trading links with the rest of the world, i.e. the country has no influence on international prices of both imported and exported products, which remain fixed in the model. The foreign trade current account balance is kept fixed against gross domestic product (GDP), thereby effectively linking external financing to the performance of the economy. The volume of investment is kept fixed relative to GDP through household savings. The exchange rate is the numeraire in the model.

We use the 2013 Burkina Faso gender-specific social accounting matrix (SAM) developed by (Souratié et *al.*, 2019), which presents 132 goods and services accounts, of which 47 are agricultural, and 74 activity accounts, of which 29 are agricultural. Labour and capital factors are disaggregated according to gender. The SAM has four household accounts (rural poor, rural non-poor, urban poor and urban non-poor), one firm account, one government account and one rest of the world account. The original SAM is aggregated into 29 industries (of which 12 are agricultural) and 29 products (of which 14 are agricultural). The values of the elasticities of substitution are taken from the literature, together with the elasticity of substitution values between male and female labour.

IV. Scenarios and results

We use the studies carried out mainly in Burkina Faso and across Western Africa and the Sahel to gather information on the likely variations in agricultural yields induced by climate change. Table 1 presents the extreme values (minimum and maximum) as predicted by these studies for the agricultural activities included in our study. The agricultural activities are ranked in descending order of sensitivity to climate change. Agricultural activities in Burkina Faso have a relatively high sensitivity to the impacts of climate change.

Table 1: Change in agricultural yields (in percentage)

	Maximum	Minimum
Fruit and vegetables	-10.0	-30.0
Livestock	-8.0	-26.0
Fisheries	-8.0	-25.9
Tubers	13.0	-25.4
Millet and sorghum	-5.0	-20.0
Oilseeds	-1.5	-19.5
Fonio	-13.0	-18.0
Forestry	-5.0	-15.0
Pulses	-1.5	-14.2
Corn	-2.3	-8.2
Rice	0.5	-4.4

Source: Authors' calculations based on estimates from (Jalloh et al., 2015; Lam et al., 2012; Nelson et al., 2010; Thomas & Rosegrant, 2015; Thornton et al., 2009)

Although the vast majority of studies show a decline in agricultural yields, the magnitude of this decline remains highly uncertain (Table 1). The uncertainty surrounding the variations in agricultural yields induced by climate change is taken into account in our study by establishing a stochastic shock. This is done in the model through several random draws (about 100) within the intervals provided by the extreme variations predicted for agricultural yields (Table 1) and applied to the value of the total factor productivity parameter of every agricultural activity.

Migration remains an important coping mechanism in the face of climate shocks (Agrawal & Perrin, 2008; Thornton & Manasfi, 2010). However, men and women are not equally likely to migrate (Balikoowa et *al.*, 2019). As there is limited evidence available concerning migration and in particular female migration in Burkina Faso, we test the sensitivity of our results through two scenarios which are based on the tendency of women to migrate. In the first scenario, the climate shock in the agricultural sector described above, is accompanied by a low tendency of women, compared to men, to migrate between rural and urban areas. In this scenario, the sensitivity of female migration to changes in the rural-urban real income ratio is much lower than that of men. We use the term "current scenario" to refer to this scenario from here on in the document. In the second scenario, we analyse the effects of the climate shock in agriculture with the assumption that women have the same tendency to migrate from rural to urban areas as men do. Thus, with respect to migration, women and men have the same degree of sensitivity to changes in the rural-urban real income ratio. The term "scenario with migration" refers to this scenario in the remainder of the paper.

The following sections present and discuss the simulation results of these two scenarios. Given that the focus of this study is on the gender distribution of the economic effects of climate change, we limit our discussion to variations in the value added of the industries (agricultural and non-agricultural) and to the variations in the value added of male and female activities. Value added is a representative indicator of the level of economic performance of both men and women in a country where self-employment (of both sexes) largely surpasses wage employment.

4.1. Impact of climate change

The negative shock to agricultural yields (Table 1) leads to a decline in agricultural value added by an average of 8.2%, ranging from -10.4% to -6.0% with a 95% confidence level (Table 2). These results are consistent with the empirical findings (Bosello et *al.*, 2017; Calzadilla et *al.*, 2013; Montaud et *al.*, 2017). The climate shock negatively affects all agricultural activities. The activities most sensitive to climate change, i.e. fruit and vegetables, and livestock farming, show a relatively greater decline in value added. The activities least sensitive to climate change, i.e. rice, corn and pulses, experience a relatively modest decline in value added. Strong variability in results can be observed for tubers and oilseeds with average decreases of 4.0% and 6.9% in value added and standard deviations of 6.0% and 6.3% respectively.

Table 2 : Percentage Changes in Value Added in the Agricultural Sector

	Mean value	Standard deviation
Fruit and vegetables	-15.4	4.2
Livestock	-11.1	3.0
Fisheries	-7.6	1.8
Tubers	-4.0	6.0
Millet and sorghum	-8.0	2.3
Oilseeds	-6.9	6.3
Fonio	-6.0	0.8
Forestry	-6.2	1.3
Pulses	-4.4	2.1
Corn	-4.3	1.3
Rice	-3.5	1.3
Agriculture	-8.2	2.2

Source: Authors, based on simulation results

The climate shock in the agricultural sector is transmitted to the non-agricultural sector through several principal channels, including the reallocation of productive factors (positive shock) and the increase in the prices of agricultural products (negative shock). The latter reduces consumers' purchasing power and therefore negatively impacts the demand for non-agricultural products. This channel is also the source of the heterogeneity of the effects of the shock across the non-agricultural industries. Indeed, the non-agricultural industries that are strongly linked to the agricultural sector, experience substantial declines in value added (Table 3).

These industries include food processing industries, manufacturing of beverages and tobacco, accommodation and food services, chemical industries and manufacturing of textiles and clothing. Apart from upstream chemical industries, the non-agricultural industries are all downstream of the agricultural sector. Thus, the decline in the supply of agricultural products, following the climate shock, contributes to the increase in the prices of agricultural products used as inputs in these industries and, consequently, increases the production costs and reduces their profitability.

Table 3: Percentage Changes in Value Added in the Non-Agricultural Sectors

	Mean value	Standard deviation
Extraction	-1.9	1.0
Food processing industries	-11.1	2.8
Manufacturing of beverages and tobacco	-7.2	1.4
Manufacturing of textiles and clothing	-5.1	3.0
Woodworking activity	-3.6	1.0
Soap and medicine	1.1	2.2
Other manufacturing industry	-4.1	1.0
Chemical industries	-5.3	1.7
Construction	-2.2	0.4
Trade	-4.7	1.1
Accommodation and food services	-6.4	1.3
Transport and Telecommunications	-3.7	0.8
Finance	-4.7	1.0
Public Administration	-3.1	0.6
Other services	-4.4	0.9
Non-agricultural sector	-3.7	0.7

Source: Authors, based on simulation results

The production factors (capital and labour) held by both men and women are heterogeneously distributed across economic activities (Appendix Table A.1). 42.2% of the factors held by women are employed in agriculture compared to 35.9% for men. In the agricultural sector, men are more involved in climate sensitive activities than women, i.e. fruit & vegetables and livestock (17.5% versus 8.3% of their factors respectively). Nevertheless, in contrast to their male counterparts, women are engaged in activities for which there is still a high degree of uncertainty in both the direction and magnitude of climate change effects, i.e. tubers and oilseeds (15.9% and 6.1% of their factors respectively).

Women are slightly more involved than men in activities that are relatively less sensitive to climate change, i.e. rice, corn, pulses and forestry (6.3% versus 4.0% of their factors respectively). Consequently, the negative effect of the climate shock is more pronounced on male agricultural activities than on female ones on average (Table 4). However, this difference is unlikely within a 5% margin of error.

Like in the agricultural industries, the production factors held by men and women are heterogeneously distributed across the non-agricultural industries (Appendix Table A.1). The production factors held by women are more prevalent in the non-agricultural industries closely related to agriculture, i.e. 6.4% of their production factors compared to 1.4% of production factors held by men. As a result, women's non-agricultural value added declines more than men's on average. It should be noted that the strong contribution of men, compared to women, in the export oriented extractive industries (more than 90% of production exported) also contributes to shelter them from the harmful effects of climate change. While this bias in favour of men is more pronounced than that of agriculture in favour of women, it is still within the 5% margin of error.

Our results show that the climate shock in agriculture is on average slightly adverse to the economic activities of women in Burkina Faso. However, given the high uncertainty about the variations in crop yields as a result of climate change, we cannot draw a robust conclusion regarding the gender distributive effects.

Table 4 : Percentage Changes in Male and Female Value Addition

	Female	Male
Agriculture	-7.4 (1.9)	-8.6 (2.3)
Non agriculture	-4.5 (0.6)	-3.3 (0.8)
All Economy	-5.7 (2.1)	-5.2 (2.3)

Source: Authors based on simulation results. Note: Standard deviations are given by the values in brackets.

4.2. Adaptation strategy to climatic conditions

The final step in our analysis is to determine whether women have any scope for adaptation to climate change. In the literature a number of adaptation options such as investments in road infrastructures, input subsidies, research and development, training and irrigation have been singled out for developing countries and evaluated by some studies (e.g. (Calzadilla, Zhu, & Rehdanz, 2014; Montaud, 2019; Montaud et *al*., 2017). In Burkina Faso, a significant number of adaptation options have already been planned by the authorities in the National Adaptation Plan (NAPA) (Crawford et *al*., 2016).

The multiple policy options and adaptation measures layed out by the NAPA largely lack empirical testing of their effects to protect women and reduce existing inequalities in the agricultural sector.

In addition to climate change adaptation policy measures, recurrent droughts are destroying economic opportunities in rural areas and forcing people to migrate. Thus, the link between migration and climate change is deeply rooted in environmental, social, and economic policies. Migration is driven by rural landlessness and environmental degradation. Thus, migration is considered to be a normal response of humans to the climate threat. In this study we simulate and compare two different female economic migration assumptions in order to determine whether economic migration is able to reduce the adverse impacts of climate change and the gender economic inequalities.

The low tendency of women to migrate has important implications for the economy and on income distribution in Burkina Faso under the climate change shock. Assuming men and women have the same tendency to migrate, the increase in the rural-urban migration of women affects negatively agricultural activities and positively non-agricultural activities (Table 5).

Table 5: Percentage Changes in Agricultural and Non-Agricultural Value Added Under Different Scenarios of Female Economic Migration

	Low female mobility	High female mobility
Agriculture	-8.2 (2.2)	-10.3 (2.1)
Non agriculture	-3.7 (0.7)	-3.2 (0.8)
All Economy	-5.5 (1.2)	-5.9 (1.2)

Source: Authors, based on simulation results. Note: Standard deviations are given by the values in brackets.

In average, the gender distributional impacts of climate change observed in the current scenario are reversed with increasing rural-urban migration of women. Nevertheless, the difference in the variation in value added between men and women remains insignificant at the 95% level of confidence.

Table 6: Percentage Changes in Male and Female Value Added Under Different Scenarios of Female Economic Migration.

	Low mobility	High mobility
Women	-5.7 (2.1)	-5.6 (2.0)
• Agriculture	-7.4 (1.9)	-9.1 (1.8)
• Non-agriculture	-4.5 (0.6)	-3.1 (0.7)
Men	-5.2 (2.3)	-5.9 (2.1)
• Agriculture	-8.6 (2.3)	-10.7 (2.2)
• Non-agriculture	-3.3 (0.8)	-3.2 (0.8)

Source: Authors, based on simulation results. Note: Standard deviations are given by values in brackets.

V. Conclusion

Climate change is happening and its adverse effects are being felt across the globe. The question of whether climate change is gender-neutral is fuelling political and scientific debates in response to this threat. Despite a vast body of literature examining the economic impacts of climate change in developing countries, little evidence is available on the gender distributional effects of climate change. To our knowledge, no study using the general equilibrium approach has yet assessed the economic impact of climate change in Burkina Faso from a gender perspective.

Using existing data on the impact of climate change on agricultural yields in Burkina Faso, we assessed the economic implications for both men and women in the country. The climate shock taking place in agriculture affects the whole economy through the backward and forward linkages of the agricultural sector with the non-agricultural sectors. Computable general equilibrium modelling was used to account for this interrelationship between sectors and industries. The climate shock is introduced using a stochastic approach to account for uncertainties surrounding the evolution of climate and its effects on agricultural yields in Burkina Faso.

Firstly, the results of the study reveal that the decline in crop yields reduces agricultural value added. On average, this decline in value added is greater for the activities which are intensive in labour and capital, held by men and because of their high vulnerability to climatic shocks (e.g. livestock). Secondly, the results show that the spill-over effect of the climate shock from the agricultural sector to the non-agricultural sectors remains unfavourable to women on average, given that they are involved in non-agricultural activities with strong downstream linkages to agriculture (e.g. agro-food and catering). Thirdly, the net average effect remains unfavourable to women as long as their tendency to migrate remains significantly lower than that of men. Finally, a robust conclusion cannot be drawn from our results given the high degree of uncertainty surrounding the impact of climate change on agricultural yields that exists in the literature.

References

Adzawla, W., Baanni, S., Yao, P., & Donkoh, S. A. (2019). Gender perspectives of climate change adaptation in two selected districts of Ghana. *Heliyon*, *5*(October), e02854. https://doi.org/10.1016/j.heliyon.2019.e02854

Agbodji, A. E., Batana, Y. M., & Ouedraogo, D. (2015). Gender inequality in multidimensional welfare deprivation in West Africa. *International Journal of Social Economics*, *42*(11). https://doi.org/http://dx.doi.org/10.1108/IJSE-11-2013-0270

Agrawal, A., & Perrin, N. (2008). *Climate Adaptation , Local Institutions , and Rural Livelihoods* (IFRI Working Paper No. W08I-6).

Ahmed, S. A., Diffenbaugh, N. S., Hertel, T. W., Lobell, D. B., Ramankutty, N., Rios, A. R., & Rowhani, P. (2011). Climate volatility and poverty vulnerability in Tanzania. *Global Environmental Change*, *21*(1), 46–55. https://doi.org/10.1016/j.gloenvcha.2010.10.003

Andersen, L. E., Verner, D., & Wiebelt, M. (2016). GENDER AND CLIMATE CHANGE IN LATIN AMERICA : AN ANALYSIS OF VULNERABILITY , ADAPTATION AND RESILIENCE BASED ON HOUSEHOLD. *Journal of International Development*. https://doi.org/10.1002/jid

Arndt, C., Benfica, R., & Thurlow, J. (2011). Gender Implications of Biofuels Expansion in Africa : The Case of Mozambique. *World Development*, *39*(9), 1649–1662. https://doi.org/10.1016/j.worlddev.2011.02.012

Arndt, C., Robinson, S., & Tarp, F. (2006). Trade Reform and Gender in Mozambique. *Nordic Journal of Political Economy*, *32*, 73–89.

Arndt, C., Robinson, S., & Willenbockel, D. (2011). Ethiopia ' s growth prospects in a changing climate : A stochastic general equilibrium approach. *Global Environmental Change*, *21*, 701–710. https://doi.org/10.1016/j.gloenvcha.2010.11.004

Arndt, C., Schlosser, A., & Strzepek, K. (2015). Climate Change and Economic Growth Prospects for Malawi : An Uncertainty Approach. *Journal of African Economies*, *23*, 83–107. https://doi.org/10.1093/jae/eju013

Arndt, C., & Tarp, F. (2000). Agricultural Technology , Risk , and Gender : A CGE Analysis of Mozambique. *World Development*, *28*(7).

Arndt, C., & Thurlow, J. (2015). Climate uncertainty and economic development : evaluating the case of Mozambique to 2050. *Climate Change*, 63–75. https://doi.org/10.1007/s10584-014-1294-x

Arora, D., & Rada, C. (2020). Gender norms and intrahousehold allocation of labor in Mozambique : A CGE application to household and agricultural economics. *Agricultural Economics*, *51*(2), 259–272. https://doi.org/10.1111/agec.12553

Balikoowa, K., Nabanoga, G., Tumusiime, D. M., Mbogga, M. S., & Balikoowa, K. (2019). Gender differentiated vulnerability to climate change in Eastern Uganda Gender di ff erentiated vulnerability to climate change in Eastern Uganda. *Climate and Development*, *0*(0), 1–11. https://doi.org/10.1080/17565529.2019.1580555

Banque Mondiale. (2014). *Levelling the field: improving opportunities for women farmers in Africa*. Washington DC.

Banque Mondiale. (2015). *Women in Agriculture : The Impact of Male Out-Migration on Women's Agency, Household Welfare, and Agricultural Productivity*. Washington DC.

Banque Mondiale. (2016). *Burkina Faso Poverty , Vulnerability , and Income Source Burkina Faso.*

Washington DC.

Bezabih, M., Chambwera, M., Stage, J., Bezabih, M., Chambwera, M., & Stage, J. (2011). Climate change and total factor productivity in the Tanzanian economy Climate change and total factor productivity in the Tanzanian economy. *Climate Policy*, *11*(6), 1289–1302. https://doi.org/10.1080/14693062.2011.579300

Bosello, F., Campagnolo, L., Cervigni, R., & Eboli, F. (2017). Climate Change and Adaptation : The Case of Nigerian Agriculture. *Environmental and Resource Economics*. https://doi.org/10.1007/s10640-016-0105-4

Bosello, F., Roson, R., & Tol, R. S. J. (2007). Economy-wide Estimates of the Implications of Climate Change : Sea Level Rise. *Environmental & Resource Economics*, 549–571. https://doi.org/10.1007/s10640-006-9048-5

Breisinger, C., Ringler, C., Aragon, C., Aragon, C., & Ecker, O. (2010). *Food Security and Economic Development in the Middle East and North Africa Current State and Future Perspectives*.

Brown, O. (2008). *Migration and Climate Change*. Genève, Suisse.

Buechler, S. (2009). Gender , water , and climate change in Sonora , Mexico : implications for policies and programmes on agricultural income- generation Gender , water , and climate change in Sonora , Mexico : implications for policies and programmes on agricultural. *Climate & Development*, *17*(1), 51–66. https://doi.org/10.1080/13552070802696912

Burkina Faso. (2018). *Deuxième programme national du secteur rural 2016-2020*. Burkina Faso.

Calzadilla, A., Zhu, T., & Rehdanz, K. (2014). Climate change and agriculture : Impacts and adaptation options in South Africa. *Water Resources and Economics*, 1–25. https://doi.org/10.1016/j.wre.2014.03.001

Calzadilla, A., Zhu, T., Rehdanz, K., Tol, R. S. J., & Ringler, C. (2013). Economywide impacts of climate change on agriculture in Sub-Saharan Africa. *Ecological Economics*, *93*, 150–165. https://doi.org/10.1016/j.ecolecon.2013.05.006

Campbell-lendrum, D., & Corvala, C. (2007). Climate Change and Developing-Country Cities : Implications For Environmental Health and Equity. *Journal of Urban Health: Bulletin of the New York Academy of Medicine*, *84*(1), 109–117. https://doi.org/10.1007/s11524-007-9170-x

Cattaneo, A., & Robinson, S. (2020). *Economic development and the evolution of internal migration. Moving in steps, returnees, and gender differences*. Rome, Italie: FAO Agricultural Development Economics.

Chindarkar, N. (2012). Gender and climate change-induced migration : proposing a framework for analysis. *Environmental Research Letters*, *7*. https://doi.org/10.1088/1748-9326/7/2/025601

Cockburn, J., Decaluwé, B., & Robichaud, V. (2008). *Trade Liberalization and Poverty : A CGE Analysis of the 1990s Experience in Africa and Asia*. (Randy Spence, Ed.). Poverty and Economic Policy (PEP) Research Network.

Crawford, A., Price-kelly, H., Terton, A., & Echeverria, D. (2016). *Review of Current and Planned Adaptation Action in Burkina Faso* (CARIAA Working Paper No. 17). Ottawa, Canada and UK Aid, London, United Kingdom.

Decaluwé, B., Lemelin, A., Robichaud, V., & Maisonnave, H. (2013). *pep -1- t the PEP standard single-country, recursive dynamic CGE model*. (Université Laval, Ed.) (Vol. 0). Québec (Canada): Partnership for Economic Policy.

Eastin, J. (2018). Climate change and gender equality in developing states. *World Development*, *107*, 289–305. https://doi.org/10.1016/j.worlddev.2018.02.021

Escalante, L. E., Maisonnave, H., & Chitiga, M. R. (2020). Do South African fiscal reforms benefit women ? *Applied Economics*, *00*(00), 1–11. https://doi.org/10.1080/00036846.2020.1813247

Escalante, L., & Maisonnave, H. (2020a). *Assessing the impacts of climate change on women ' s poverty and domestic burdens : A Bolivian case study*.

Escalante, L., & Maisonnave, H. (2020b). *Climate change, labour markets and poverty in Bolivia: Why does gender matter?* Retrieved from https://www.gtap.agecon.purdue.edu/resource

FAO. (2008). *climate change, water and food security*. Rome, Italie.

FAO. (2011a). *The role of women in agriculture* (ESA Working Papers). Rome, Italie.

FAO. (2011b). *The state of food and agriculture 2010-2011*. Rome, Italie: FAO Agricultural Development Economics.

FAO. (2014). *Analyse des dépenses publiques en soutien à l'agriculture et l'alimentation au Burkina Faso 2006-2013*. Rome, Italie.

Fontana, M. (2001). *Modelling the effects of trade on women : a closer look at Bangladesh* (IDS working papers No. 139). Brighton.

Fontana, M. (2002). Modelling the effects of trade on women: the case of Zambia. *IDS Working Paper*, (155), 46.

Fontana, M. (2014). Gender in economy-wide modelling. In : S.M. Rai and G. Waylen (Ed.), *New Frontiers in Feminist Political Economy* (Routledge, pp. 157–177). New York.

Fontana, M., & Wood, A. (2000). Modeling the Effects of Trade on Women , at Work and at Home. *World Development*, *28*(7).

Gebreegziabher, Zenebe; Jesper, Stage; Alemu, Mekonnen; Atlaw, A. (2015). Climate change and the Ethiopian economy : a CGE analysis. *Environment and Development Economics*, *21*, 205–225. https://doi.org/10.1017/S1355770X15000170

Goh, A. H. X. (2012). *Sex hormones in papillary carcinoma of thyroid Gland and pleomorphic adenoma of parotid gland. CAPRi Working Paper No. 106* (Vol. 114). https://doi.org/10.3109/00016489409126046

Harris, J. R., & Todaro, M. P. (1970). Migration , Unemployment and Developmnent : A Two-Sector Analysis. *The American Economic Review*, *60*(1), 126–142.

Henderson, B., Cacho, O., Thornton, P., Wijk, M. Van, & Herrero, M. (2018). The economic potential of residue management and fertilizer use to address climate change impacts on mixed smallholder farmers in Burkina Faso. *Agricultural Systems*, *167*(January), 195–205. https://doi.org/10.1016/j.agsy.2018.09.012

Herrera, R., & Ilboudo, L. (2012). Les défis de l ' agriculture paysanne : le cas du Burkina Faso. *L'Homme & La Société*, *I*(183–184), 83–95.

Hidalgo, D. M., Herrero, M., Voil, P. De, Thornton, P., Wijk, M. Van, Rodriguez, D., … Rigolot, C. (2015). Assessing potential climate change impacts in smallholder systems in Burkina Faso. *Climate Smart Agriculture 2015*, (Mars 2015). https://doi.org/Montpellier, France. 2015. 〈hal-01195409〉

Hunter, L. M., & David, E. (2009). *Climate Change and Migration : Considering the Gender Dimensions*.

Integrated Water Resources Management (IWRM). (2001). *État des lieux des ressources en eau du Burkina Faso et de leur cadre de gestion*. Burkina Faso. Retrieved from http://www.hubrural.org/IMG/pdf/burkina_gire_etat_des_lieux.pdf

IPCC. (2001). *C LIMATE C HANGE 2001 : the scientific basis*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA,.

IPCC. (2007). *Changements Climatiques 2007: rapport de snthèse*. Genève, Suisse.

IPCC. (2014a). *Climate Change 2014 Impacts , Adaptation , and Vulnerability. Working group II contribution to the fifth assessment report of the Intergovernmental Panel on Climate Change. Technical Report.* (. Cambridge University Press & Cambridge, Eds.). UK/New York, USA: . Cambridge University Press, Cambridge.

IPCC. (2014b). Summary for Policymakers. In R. Edenhofer, O., J. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, & T. Z. and J. C. M. Savolainen, S. Schlömer, C. von Stechow (Eds.), *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge). Cambridge, United Kingdom and New York, NY, USA.

J S Juana , K M Strzepek, J. F. K. (2008). Households ' welfare analyses of the impact of global change on water resources in South Africa Households ' welfare analyses of the impact of global change on water resour. *Agrekon: Agricultural Economics Research, Policy and Practice in Southern Africa*, *47*(December 2014), 37–41. https://doi.org/10.1080/03031853.2008.9523802

Jalloh, A., Nelson, G. C., Thomas, T. S., & Roy-macauley, H. (2015). *West African agriculture and climate change : a comprehensive analysis*. (A. Jalloh, G. C. Nelson, T. S. Thomas, & and H. R.-M. Robert Zougmoré, Eds.). Washington: International Food Policy Research Institute;

Kaczan, D. J., & Orgill-Meyer, J. (2020). The impact of climate change on migration : a synthesis of recent empirical insights. *Climatic Change*, 281–300.

Kima, S. A., Okhimamhe, A. A., Kiema, A., Zampaligre, N., & Sule, I. (2015). Adapting to the impacts of climate change in the sub-humid zone of Burkina Faso , West Africa : Perceptions of agro-pastoralists. *Pastoralism: Research, Policy and Practice*. https://doi.org/10.1186/s13570-015-0034-9

Knox, J., Hess, T., Daccache, A., Xiong, W., Holman, I., Lin, E., … Burke, M. B. (2008). Why are agricultural impacts of climate change so uncertain ? The importance of temperature relative to precipitation. *Environmental Research Letters*, *3*. https://doi.org/10.1088/1748-9326/3/3/034007

Lam, V. W. Y., Cheung, W. W. L., Swartz, W., & Sumaila, U. R. (2012). Climate Change Impacts on Fisheries in West Africa : Implications for Economic , Food and Nutritional Security Climate change impacts on fisheries in West Africa : implications for economic , food and nutritional security. *African Journal of Marine Science*, *34*(1), 103–117. https://doi.org/10.2989/1814232X.2012.673294

Letta, M., Montalbano, P., & Tol, R. S. J. (2018). Temperature shocks , short-term growth and poverty thresholds : Evidence from rural Tanzania. *World Development*, *112*, 13–32. https://doi.org/10.1016/j.worlddev.2018.07.013

Marchiori, L., Maystadt, J.-F., & Schumacher, I. (2012). The impact of weather anomalies on migration in sub-Saharan Africa. *Journal of Environmental Economics and Management*, *63*, 355–374. https://doi.org/10.1016/j.jeem.2012.02.001

Mathieu, Ouedraogo; Leopold, Some and Youssouf, D. (2006). *Economic impact assessment of climate change on agriculture in Burkina Faso : A Ricardian approach. CEEPA Discussion Paper No. 24*. University of Pretoria.

Mertz, O., Halsnæs, Æ. K., & Olesen, Æ. J. E. (2009). Adaptation to Climate Change in Developing Countries. *Environmental Management*, *43*, 743–752. https://doi.org/10.1007/s00267-008-9259-3

Millner, A., & Dietz, S. (2015). Adaptation to climate change and economic growth in developing countries. *Environment and Development Economics*, *20*(3), 380–406. https://doi.org/10.1017/S1355770X14000692

Ministry of the Environment and the Living Environment. (2007). *Programme d'action nationale d'adaptation a la variabilité et aux changements climatiques (PNA du Burkina Faso)*. Burkina Faso. Retrieved from https://unfccc.int/resource/docs/napa/bfa01f.pdf

Montaud, J. (2019). Agricultural drought impacts on crops sector and adaptation options in Mali: a macroeconomic computable general equilibrium analysis. *Environment and Development Economics*, 1–23. https://doi.org/10.1017/S1355770X19000160

Montaud, J., Pecastaing, N., & Tankari, M. (2017). Potential socio-economic implications of future climate change and variability for Nigerien agriculture : A countrywide dynamic CGE-Microsimulation analysis. *Economic Modelling*, *63*(February), 128–142. https://doi.org/10.1016/j.econmod.2017.02.005

Muller, C., Cramer, W., Hare, W. L., & Lotze-Campen, H. (2011). Climate change risks for African agriculture. *Proceedings of the National Academy of Sciences*, *108*(11), 4313–4315. https://doi.org/10.1073/pnas.1015078108

National Institute of Statistics and Demography. (2016). *Enquête nationale sur l'emploi et secteur informel (ENESI-2015): Chômage*. Burkina Faso.

National Institute of Statistics and Demography. (2017). *Tableau de bord social du burkina faso 2017*. Burkina Faso. Retrieved from http://www.insd.bf/contenu/pub_periodiques/tableaux_de_bord/TBS/TBS_2017.pdf

Nelson, G. C., Rosegrant, M. W., Palazzo, A., Gray, I., Ingersoll, C., Robertson, R., … Zhu, T. (2010). *Food Security, Farming, and Climate Change to 2050: Scenarios, Results, Policy Options*. Washington DC: International Food Policy Research Institute.

OCDE. (2018). *Etude pays SIGI-Burkina Faso*. Paris, France.

Ouedraogo, M. (2012). Impact des changements climatiques sur les revenus agricoles au Burkina Faso. *Journal of Agriculture and Environment for International Development*, *106*(1file:///C:/Users/Boureima/Desktop/CHANGEMENT CLIMATIQUE PAPIER/Climate change/waongo2015.pdffile:///C:/Users/Boureima/Desktop/CHANGEMENT CLIMATIQUE PAPIER/Climate change/waongo2015.pdf), 3–21.

Paudyal, B. R., Chanana, N., Khatri-chhetri, A., & Sherpa, L. (2019). Gender Integration in Climate Change and Agricultural Policies : The Case of Nepal. *Policy and Practices Reviews*, *3*(August), 1–10. https://doi.org/10.3389/fsufs.2019.00066

PNUD. (2018). *Indices et indicateurs de développement humain 2018*. Washington DC, USA.

PNUD. (2019). *Rapport sur le développement humain 2019: Les inégalités de développement humain au XXIe siècle*. Washington DC.

Rao, N., Lawson, E. T., Raditloaneng, W. N., Solomon, D., Angula, M. N., Rao, N., … Solomon, D. (2019). Gendered vulnerabilities to climate change : insights from the semi-arid regions of Africa and Asia. *Climate and Development*, *11*(1). https://doi.org/10.1080/17565529.2017.1372266

Reid, H., Sahlén, L., Stage, J., & Macgregor, J. (2008). Climate change impacts on Namibia ' s natural resources and economy Climate change impacts on Namibia ' s natural resources and economy. *Climate Policy*, *8*(December 2014), 37–41. https://doi.org/10.1080/14693062.2008.9685709

Sassi, M., & Cardaci, A. (2013). Impact of rainfall pattern on cereal market and food security in Sudan : Stochastic approach and CGE model. *JOURNAL OF FOOD POLICY*.

https://doi.org/10.1016/j.foodpol.2013.06.002

Siddiqui, R. (2009). Modeling Gender Effects of Pakistan ' s Trade Liberalization. *Feminist Economics*, *15*(3), 287–321. https://doi.org/10.1080/13545700902964295

Somé, L., Jalloh, A., Zougmore, R., Nelson, G., & Thomas, T. S. (2012). *West African Agriculture and Climate Change : A comprehensive analysis - Burkina Faso*. Washington DC.

Souratié, W., Koinda, F., Decaluwé, B., & Samandoulougou, R. (2019). Politiques agricoles , emploi et revenu des femmes au Burkina Faso 1. *Revue d'économie Du Développement*, *27*(3), 103–130. https://doi.org/10.3917/edd.333.0103

Sultan, B., Defrance, D., & Iizumi, T. (2019). Evidence of crop production losses in West Africa due to historical global warming in two crop models. *Scientific Reports Nature Research*, (October 2018), 1–15. https://doi.org/10.1038/s41598-019-49167-0

Thomas, T., & Rosegrant, M. (2015). Climate change impact on key crops in Africa: Using crop models and general equilibrium models to bound the predictions. In Food Agriculture Organization of the United Nations (FAO (Ed.), *Climate change and food systems: global assessments and implications for food security and trade* (pp. 1–356). Rome, Italie.

Thornton, P K, Steeg, J. Van De, Notenbaert, A., & Herrero, M. (2009). The impacts of climate change on livestock and livestock systems in developing countries : A review of what we know and what we need to know. *Agricultural Systems*, *101*(3), 113–127. https://doi.org/10.1016/j.agsy.2009.05.002

Thornton, Philip K, Ericksen, P. J., Herrero, M., & Challinor, A. J. (2014). Climate variability and vulnerability to climate change : a review. *Global Change Biology*, *20*(11), 3313-3328file:///C:/Users/Boureima/Desktop/CC_gend. https://doi.org/10.1111/gcb.12581

Thornton, T. F., & Manasfi, N. (2010). Adaptation — Genuine and Spurious Demystifying Adaptation Processes in Relation to Climate Change. *Environment and Society: Advances in Research*, *1*(2010), 132–155. https://doi.org/10.3167/ares.2010.010107

Thurlow, J. (2006). *Has trade liberalization in South Africa affected men and women differently?* (DSGD Discussion Paper No. 36). Washington DC.

Thurlow, J., Dorosh, P., & Yu, W. (2012). A Stochastic Simulation Approach to Estimating the Economic Impacts of Climate Change in Bangladesh. *Review of Development Economics*, *16*(3), 412–428. https://doi.org/10.1111/j.1467-9361.2012.00671.x

Waongo, M., Laux, P., & Kunstmann, H. (2015). Agricultural and Forest Meteorology Adaptation to climate change : The impacts of optimized planting dates on attainable maize yields under rainfed conditions in Burkina Faso. *Agricultural and Forest Meteorology*, *205*, 23–39. https://doi.org/10.1016/j.agrformet.2015.02.006

Williams, P. A., Crespo, O., Abu, M., & Simpson, N. P. (2018). A systematic review of how vulnerability of smallholder agricultural systems to changing climate is assessed in Africa A systematic review of how vulnerability of smallholder agricultural systems to changing climate is assessed in Africa. *Environmental Research Letters*, *13*(103004).

Wollenberg, E., Thornton, P., Vermeulen, S., Zougmore, R., Nelson, G., Kristjanson, P., … Aggarwal, P. (2012). Climate change , agriculture and food security : a global partnership to link research and action for low-income agricultural producers and consumers. *Environmental Sustainability*, (January), 128–133. https://doi.org/10.1016/j.cosust.2011.12.004

World Bank. (2013a). *FY13–16 Country partnership strategy for Burkina Faso*. Burkina Faso. Retrieved from https://documents1.worldbank.org/curated/en/937251468005970222/pdf/787930REVISEDb0IC00IDA0R20130022503.pdf

World Bank. (2013b). *Turn Down the heat: climate extremes, regional impacts, and the case for resilience*. Washington DC: World Bank.

World Bank. (2019). *World Development Report 2019: The Changing Nature of Work*. Washington DC, USA. https://doi.org/doi:10.1596/978-1-4648-1328-3

Zacharias, A., Masterson, T., Rios-avila, F., Kim, K., & Khitarishvili, T. (2018). *Understanding the interlocking of income and time deficits for men and women in Ghana and Tanzania: revisiting poverty measurement, rethinking policy responses*. New York.

Zidouemba, P. R. (2017). Economy-wide Implications of Climate Change in Burkina Faso. *Economics Bulletin*, *37*(4), 2797–2808.

Zougmoré, R., Partey, S., Ouédraogo, M., Omitoyin, B., Thomas, T., Ayantunde, A., … Jalloh, A. (2016). Toward climate - smart agriculture in West Africa : a review of climate change impacts , adaptation strategies and policy developments for the livestock , fishery and crop production sectors. *Agriculture & Food Security*, 1–16. https://doi.org/10.1186/s40066-016-0075-3

Appendix

Table A. 1 : Distributional share of value added by gender (in percentage)

	Men	Women	Overall
Fruit and vegetables	1.6	1.7	1.6
Livestock	15.9	6.6	12.1
Fishing and hunting	0.5	0.1	0.3
Tubers	2.7	3.4	3.0
Millet and sorghum	5.0	6.1	5.4
Oilseeds	3.4	12.5	7.1
Fonio	0.0	0.1	0.0
Forestry	2.5	5.3	3.6
Pulses	1.0	1.5	1.2
Corn	2.2	2.9	2.5
Rice	0.8	1.9	1.3
Extraction	10.1	6.2	8.5
Food and beverage industry	1.0	2.8	1.7
Manufacture of beverages and tobacco	0.1	2.6	1.1
Manufacture of textiles and clothing	0.1	0.1	0.1
Woodworking activity	0.6	0.7	0.6
Soap and medicine	0.0	0.1	0.1
Manufacturing industry	1.0	1.3	1.1
Other chemical products	0.1	0.3	0.2
Construction	7.6	0.7	4.8
Trade	8.5	18.3	12.5
Accommodation and catering	0.1	0.6	0.3
Transport and Telecommunications	8.0	0.5	5.0
Finance	2.2	1.7	2.0
Public Administration	20.8	18.0	19.6
Other services	3.9	3.9	3.9
Agriculture	35.9	42.2	38.5
Non-agriculture	64.1	57.8	61.5
National economy	100,0	100,0	100,0

Source: Authors using the SAM of Burkina Faso 2013.