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Economywide impact of climate shock on agricultural sector, women employment and poverty: a Burkina Faso case study

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Introduction: The study examines the impact of climate shocks in Burkina Faso, concentrating on agriculture, food security, rural income, and women's employment. It analyses how these interconnected effects play a role in exacerbating poverty, emphasising the pressing need for adaptation and mitigation strategies.

Methods: The study utilises a recursive dynamic gender-disaggregated computable general equilibrium model linked with a microsimulation model following a top-down methodology to examine how climate shocks influence the agricultural sector, women's employment, and poverty in Burkina Faso. In this framework, climate change is modelled by decreased agricultural crop yields under scenarios of moderate and severe climate shocks.

Results: Findings are that under both moderate and severe scenarios, there are negative impacts that become more detrimental in the severe climate shock scenario. Rural areas compared to urban areas experience reductions in the rate of participation in economic activities and increase the burden of domestic work, particularly for women and, more so, for skilled women. Furthermore, the simulations show a negative impact on poverty, with rural households suffering the greatest and increasing the vulnerability of rural women.

Discussion: The study offers valuable information and guidance to policymakers as they formulate and implement gender aware strategies to tackle the rise in poverty, inequality and social exclusion induced by climate change. These findings show that agricultural and climate policies should focus on targeted investments and actions that consider the specific needs of each sector and support the most vulnerable people.

KEYWORDS

Burkina Faso, climate change, dynamic model, domestic work, gender, poverty

1 Introduction

Climate change is widely acknowledged as one of the most serious concerns facing humanity. Although all nations are affected by the effects of climate change, poor nations are the most exposed (IPCC, 2012). Even within these vulnerable countries, the most vulnerable populations are the most affected (Denton, 2002; Edvardsson Björnberg and Hansson, 2013; Goh, 2012; Quisumbing et al., 2018; Simbanegavi and Arndt, 2014). Women are affected the most among vulnerable social groups due to their reliance on natural resources and their lower capacity to protect themselves from exogenous shocks (Chitiga-Mabugu et al., 2023; Denton, 2002; Eastin, 2018). Indeed, despite the growing body of knowledge on the impacts of weather events on economies around the world, evidence on the impacts on women in developing countries and particularly in sub-Saharan Africa remains limited.

Burkina Faso is an interesting case study, as it is a Sahelian country that has been identified as particularly vulnerable to the social and ecological effects of changes in temperature and rainfall. In fact, the special IPCC report on climate change and land characterized Burkina Faso, like other countries in the Sahel, as a country where human security is at risk due to projected impacts of climate change (IPCC, 2019). Burkina Faso is ranked among the most vulnerable countries to climate change in the world (Röhrig et al., 2021). Furthermore, the country is dependent on rainfed agriculture for food security and export income (Brown and Crawford, 2008). Furthermore, the agricultural sector is identified as the most vulnerable in Burkina Faso. Agriculture is the mainstay of the economy, accounting for 86% of employment and roughly 30% of the gross domestic product (GDP). Indeed, past climatic events, such as the 2009 floods, caused a 46% decrease in the expected value added in the agricultural sector, 29% in infrastructure, and 25% in social services (World Bank, 2010). For the 2020 floods, a total of 7,341 affected people were recorded, of whom 33.18% were women, 50.34% were children, and 16.48% were men (MEEVCC, 2021). In addition, Traore and Owiyo (2013) point out that drought events in northern Burkina Faso have resulted in agricultural production losses of between US$ 577 and US$ 636 per household per year and drought-induced livestock losses are estimated at between US$ 1922 and US$ 8,759 per herd.

Since droughts and floods are frequent and mostly localized in rural areas where economic infrastructure (drinking water and irrigation infrastructure and roads) is poor or non-existent, this makes rural areas vulnerable to climate change. Both Men and women are thereupon affected differently depending on their initial disposition. While the literature shows that women are not inherently more exposed or vulnerable to climate change than men, however, social norms (e.g., lack of land ownership and decision-making power), control over household assets, family burdens (domestic work) and reduced access to water and food mean that women are more likely to experience climate impacts differently (Eastin, 2018; Goh, 2012). Previous research shows that gender-differentiated vulnerability to climate change is most pronounced in the agricultural sector (Caretta and Börjeson, 2015; Su et al., 2017) and water sector (Sinharoy and Caruso, 2019; Sultana, 2018) and health sectors (Castañeda et al., 2020; Sorensen et al., 2018). Consequently, predictions show that extreme weather events will increase in frequency and intensity in the coming years (IPCC, 2022). This would contribute to the exacerbation of existing economic and social disparities and discrimination.

Burkina Faso shows significant socioeconomic and gender disparities with a gender inequality index of 0.621 while the average for sub-Saharan Africa is 0.569 (UNDP, 2022). In the labor market, women are in a limited number of economic sectors and are more predisposed to vulnerable employment than men (88% versus 82%) (World Bank, 2021). Furthermore, gender inequalities are pronounced because most women are engaged in unpaid work, with a labor market participation rate of 57% compared to 73% for men (World Bank, 2021). However, in non-market activities, women spend more time than men. Women allocate 4.544 h per day to domestic work compared to 0.475 h per day for men (MINEFID, 2020). Thus, heavy domestic burdens result in women participating less in paid labor markets, thus hindering their economic empowerment. For those in the paid labor market, women are more affected by unemployment than men (9.3% for women versus 4.1% for men) (INSD, 2016). Furthermore, in paid activities, underemployment affects 30.3% of women versus 16.3% of men (INSD, 2016). Insofar as gender equality is a lever for development, as the literature shows, the persistence of this gender gap in Burkina Faso constitutes a serious threat to the timely achievement of the Sustainable Development Goals (SDGs) of the United Nations.

This paper aims to assess the impact of climate change on production, paid work, and domestic work of men and women, as well as poverty in Burkina Faso. Several studies have evaluated the economic and social impacts of climate change in Burkina Faso (Sawadogo, 2022; World Bank, 2019; Zidouemba, 2017), of which only (Sawadogo, 2022) has addressed the impact of climate changes on marginalized groups. Furthermore, in the existing literature, studies that take into account vulnerable populations, particularly women, are partial equilibrium studies (Adzawla et al., 2019; Andersen et al., 2016; Eastin, 2018; Quisumbing et al., 2018). These studies show that the impacts of climate change are not gender neutral. However, these studies cannot capture the implications of climate change, both direct and indirect, on the whole economy. Other studies have used computable general equilibrium modelling to take into account the impact of climate change on the agricultural sector and the consequences for non-agricultural sectors, households, businesses, government and the rest of the world (Arndt et al., 2011, 2012; Arndt and Tarp, 2000; Bosello et al., 2017; Escalante and Maisonnave, 2022a, 2022b; Montaud et al., 2022; Montaud, 2019; Montaud et al., 2017). However, gender-focused macroeconomic case studies providing a comprehensive general equilibrium analysis of climate change are rare (see Chitiga-Mabugu et al., 2023).

However, in existing literature, attempts to integrate gender into CGE modelling date back to the 2000s, with studies by Arndt and Tarp (2000), Cockburn et al. (2007), Fofana (2003), Fontana (2001, 2004), and Fontana and Wood (2000). These studies have focused more on the impact of trade liberalization, tax policies, or exogenous shocks on gender disparities by disaggregating the labor input by gender (Arndt and Tarp, 2000; Chitiga et al., 2021; Escalante et al., 2020; Latorre, 2016; Souratié et al., 2019). Among these studies, others such as Escalante and Maisonnave (2022a, 2022b), Fofana et al. (2003), Fontana (2004) and Fontana and Wood (2000) have also considered, in addition to the disaggregation of the labor factor, the allocation of time between domestic work, market work and leisure in CGE models. Our study aims to contribute to a more in-depth analysis of gender inequalities by taking into account the difference in time allocation between paid and unpaid work between men and women in the context of climate change in Burkina Faso.

However, in the context of climate change, it is still early days for CGE modelling to take into account inequalities in the allocation of time between domestic work and paid work between men and women. Indeed, Escalante and Maisonnave (2022a) analyze the impact of climate change on domestic work in Bolivia and find a decline in employment and an increase in the burden of domestic work, especially for women. In another study, Escalante and Maisonnave (2022b) find that climate disasters between 2013 and 2014 in Bolivia had a negative impact on employment and increased the domestic workload of women. These studies are static in nature and do not allow for the observation of short-, medium- and long-term impacts of climate change. This study contributes to this literature by using dynamic CGE modelling to understand the long-term effects of climate change.

With the help of a carefully designed gender-sensitive macro–micro sequential dynamic model for Burkina Faso, this study assesses the effects of climate change on the agricultural sector, women's employment, and poverty. From an operational standpoint, we implement a recursive dynamic CGE model. In this framework, economic equilibrium is computed period by period, without assuming perfect foresight on the part of agents. At each step, exogenous variables are updated using population growth rates, and economic decisions are based solely on current and historical information. This iterative, recursive dynamic structure contrasts with forward-looking dynamic models, in which agents optimize over an intertemporal horizon under rational expectations. The use of the recursive dynamic model makes it possible to capture the long-term impacts of the predicted decline in crop yields by 2050 on the entire economy of Burkina Faso. However, the dynamic recursive CGE model does not allow for distributional analysis, so by connecting it to a microsimulation model, we can analyze the distribution effects of climate shocks. The rest of the paper is arranged as follows. Section 2 develops a methodological framework. We also present the data used and the simulation scenario. Section 3 presents and discusses the results of the different simulations. Section 4 concludes and considers the wide implications of this study.

2 Methodology and data

2.1 CGE model

Various methods have been tried to assess the impact of climate shocks (see (Arndt et al., 2014; Asafu-Adjaye, 2014; Chitiga-Mabugu et al., 2023). These methods can be grouped into two categories: macro- and micro-approaches. The micro approach uses survey data at the household or plot level to estimate the direct or indirect effects of climate shocks on household conditions and welfare or on agricultural production. The direct effects of climate shocks are reflected in agricultural products purchased directly by households. The indirect effects of climate shocks are more complex and affect household expenditures. For example, losses in agricultural production contribute to increased food purchasing costs. The proportion of agricultural items that make up a household's budget determines how much each household group is impacted by these effects. For this, a table of input and outputs, as well as survey information on household spending, is needed.

Macroeconomic approaches assess the impact of climate shocks on macroeconomic variables such as GDP, prices, sectoral output, and employment. This group of models includes computable general equilibrium models, which simulate the functioning of the economy, taking into account the structure of the economy and the interactions between sectors and agents, as well as the direct and indirect effects of exogenous shocks and macroeconomic policies (e.g., the standard PEP models and the IFPRI model). The main limitation of macro-models is that they do not quantify the distributional and poverty effects within the population as microeconomic assessment do.

To assess the impacts of climate shocks on the agricultural sector, women's employment, and poverty in Burkina Faso, this study uses the PEP 1-t CGE[1] model developed by Decaluwé et al. (2013). Studies such as Montaud et al. (2022), Montaud (2019), and Montaud et al. (2017) have already used this model to assess the impacts of climate change. To better take into account the characteristics of the Burkina Faso economy, several modifications have been made to the standard model, as presented in the following.

According to the structure of the Social Accounting Matrix (SAM), the model has 32 activities and 35 products. Each production sector is confronted with a constant return to scale production technology presented in a four-level nested production process. At the first level, the output of each sector is a combination of value-added and intermediate consumption through a Leontief-type function. At the second level, a constant elasticity of substitutions (CES) function is used in the value-added model to simulate the substitution of composite labor and composite capital. At the same level, intermediate consumption is assumed to be perfectly complementary and combined according to a Leontief-type production function. Skills are used to break down composite labor (skilled and unskilled labor) according to a CES function at the third level, whereas composite capital is a CES function of nonagricultural capital and agricultural capital. Labor demand is a CES function between male and female labor at the fourth level and for each type of skill. To reflect the rigidity of the substitution between men and women labor, we adopt low elasticity of substitution values provided by Fontana and Wood (2000) and Fofana et al. (2003), which are set at 0.5 and 0.7 for skilled and unskilled workers, respectively. A low elasticity of substitution is associated with more rigid gender roles in both economic activities and household responsibilities. Indeed, Udry (1996) demonstrates that rigid gender-based divisions of responsibilities and decision-making power within households in Burkina Faso constrain the reallocation of labor between men and women. The gender rigidity of labor allocation better reflects the structural and cultural barriers observed in real labor markets. As a result, distributional outcomes become more sensitive to gender dynamics, allowing a more accurate analysis of gender-specific vulnerabilities or opportunities in the scenarios studied.

In line with the SAM, the model has four different types of institutions: households, businesses, government, and the rest of the world. Two groups of households are distinguished: rural and urban households. Each of the households derives its income from the remuneration of labor, capital, and transfers from other economic agents. Rural households derive 67.4% of their income from capital, 16.5% from transfers from other agents, and 16.1% from labor income. However, urban households derive their income from labor income (60.8%), return on capital (28.2%), and transfers from other agents (11.0%).

Total household income is used for the payment of direct taxes, transfers, savings and, mainly, the consumption of goods and services, which is specified with a linear expenditure system (LES) utility function. In fact, rural households allocate 79.8% of their income to the consumption of goods and services, 11.3% to transfers, 0.6% to direct taxes, and 8.2% to savings. Urban households, on the other hand, allocate 80.4% of their income to the consumption of goods and services, 8.1% to transfers, 4.4% to direct taxes, and 7.2% to savings.

As for companies, they mainly derive their income from return on capital and transfers from other institutions. They pay taxes on income, dividends to other institutions and the remainder is their savings. Government income comes from direct taxes paid by households and businesses, indirect taxes (import taxes, commodity taxes, and production taxes), and transfers from other institutions. The government uses its income for public expenditure (the provision

1 The Supplementary material contains all the equations and variables of the CGE model and presents the calibration of the various parameters of these equations.

of public goods), for the payment of transfers to nongovernmental institutions, and the remainder forms savings.

Burkina Faso has economic and trade relations with the rest of the world, importing goods and services and paying transfers and capital income. The country also exports products and receives transfers from the rest of the world. To model the relations between Burkina Faso and the rest of the world, we use the traditional Armington approach, which states that if the country wants to increase its market share in the world market, it must be more competitive.

Consistent with the objective of this study, we depart from the standard PEP-1-t model, which is considered an exogenous labor supply. Instead, we consider an endogenous labor supply that takes into account a gender dimension and a time constraint depending on the time households spend on paid and unpaid domestic work. According to Cockburn et al. (2007), both men and women devote a considerable proportion of their time to domestic work, which limits the time they can free up for paid work. Indeed, based on the results of the 2018 Burkina Faso study on social institutions and gender equality, women spend an average of 3.27 h per day on activities such as fetching water for household needs, collecting firewood, cooking for the household, maintaining the yard, cleaning clothes, providing care, and shopping for food, compared to only 0.58 h for men (OECD-INSD-MFSNF, 2018). Additionally, considering the residence and qualification of the respondents, unskilled women in rural areas spend an average of 3.28 h per day on domestic work compared to 0.57 h for unskilled men in rural areas. Similarly, skilled rural women spent an average of 3.28 h per day on domestic work compared to 0.62 h for skilled rural men. In urban areas, unskilled women spend an average of 3.32 h per day on housework compared to 0.63 h for unskilled men, and skilled women spend an average of 3.15 h compared to 0.53 h for men on housework.

CGE models incorporating the modelling of unpaid work propose to construct a gender-sensitive SAM by including sectors not counted in GDP such as domestic work and leisure (e.g., Cockburn et al. (2007) and Fofana (2015) for South Africa; Fontana (2004) and Fontana and Wood (2000) for Bangladesh and Siddiqui (2009) for Pakistan). Due to a lack of detailed information to introduce domestic activities in the Burkina Faso SAM, we consider an explicit labor supply determined by households, similar to Escalante and Maisonnave (2022a, 2022b) for Bolivia, Fofana et al. (2003) for Nepal and Terra et al. (2009). As in Terra et al. (2009), we also incorporate a labor supply by gender and skill level.

Thus, like Escalante and Maisonnave (2022a, 2022b), we assume that the maximum amount of time (measured in hours) available to the household on a daily basis is spent between paid work in the market economy, leisure and domestic production (e.g., childcare, fetching water and firewood and cooking, etc.). The household therefore maximizes its utility under the constraint of their total income, which is the sum of labor income, capital income, transfers from other agents, and the value of household production.

Then, the time allocated to nonmarket activity produces a new good called "home-produced goods," which is made up entirely of labor and consumed entirely by households. In addition, the value of these commodities is equal to the value of the labor used in their production, where non-market labor is priced at its opportunity cost, as measured by market wage rates. The production function of the "home-produced goods" follows a CES type function with a low elasticity of substitution between male and female labor.

In terms of closure, we assume that the nominal exchange rate is the numeraire of the model. We then consider the small-country hypothesis for Burkina Faso; whereby international prices are exogenous. Additionally, we assume that the current account balance, the government expenditure on goods and services, and all tax rates (direct, indirect, import, and producer) are fixed. We further assume that capital is sector-specific, while labor is mobile across sectors. To develop the business-as-usual (BAU) trajectory over time, we assume that the stock of capital increases between periods given new investments in the sectors. The allocation of new private investment follows the accumulation equation of Jung and Thorbecke (2003). Labor supply is assumed to grow at the rate of population growth and all variables (except prices) will grow at the rate of population growth, allowing us to have a regular path.

Finally, the robustness of our results depends on the assumptions underlying the model. First, assumptions related to the substitution elasticities between male and female labor, as well as between skilled and unskilled workers, influence the extent to which labor can be reallocated in response to shocks. The values assigned to these elasticities may lead to either an overestimation or an underestimation of the distributional effects. Second, the assumption of an endogenous labor supply that responds to income and price changes makes the results sensitive to the chosen income elasticities. Since these values are drawn from previous studies conducted in other developing countries (owing to the lack of local estimates), they can overstate or understate labor market outcomes. Third, the representation of domestic production and unpaid care work is based on assumptions regarding minimum consumption requirements and time allocation. If these are poorly specified, they can lead to underestimation or overestimation of gender-specific impacts. Fourth, household behavior, particularly consumption decisions, is modelled using an LES (Linear Expenditure System) function, which may not fully capture the complexity of real-world situations. These simplifications, while necessary to make the model operational, also limit the robustness of certain microlevel outcomes. To address these limitations, we performed sensitivity analyses on key parameters and assessed the stability of the results under alternative assumptions.

2.2 Linking the CGE model results with the micro module

Using only the CGE model, we cannot perform poverty analysis. Thus, we use the top-down nonbehavioral approach presented in (Cockburn et al., 2014). Once the CGE model is run, changes in the consumer price index and total nominal household consumption expenditure are passed from the CGE model to the household living conditions survey data. As a result, per capita consumption expenditure and the national poverty line change, and poverty indicators are calculated based on the new per capita expenditure and the new poverty line. In Burkina Faso, the majority of households (85.1%) are headed by men, meaning that poverty applies much more to male-headed households than to female-headed households. Therefore, in our analysis, we distinguish between homes with male and female heads in both rural and urban areas, resulting in four groups of households.

We calculate Foster-Greer-Thorbecke (FGT) indicators (Foster et al., 1984) using per capita household expenditure and the poverty line. The FGT0 index measures the prevalence of poverty, while the FGT1 index indicates the extent to which poor households are below the poverty line, and the FGT2 index measures the severity of poverty. By comparing the poverty indices in the climate shock scenarios and the BAU scenario, we gain an understanding of the changes in poverty levels resulting from the climate change scenarios.

2.3 Data

The SAM used to calibrate the CGE model is that of the Ministry of Agriculture and Hydro-Agricultural Development (MAAH, 2016), updated to the 2018 data. The SAM was updated in 2018 to ensure consistency with new data from the RCP scenarios covering the 2018–2050 period. This year also corresponds to a national household living conditions survey, allowing for harmonization of the datasets used. The SAM has 32 industries (including 16 agricultural sectors) and 35 commodities. Additional data, namely income and trade elasticities from Cockburn et al. (2016) and labor market elasticities from Fofana et al. (2003) and Fontana and Wood (2000), are used to operationalize the model. To analyze the impacts of poverty, the 2018 National Survey of Household Living Conditions served as the basis for the micro-data that we used (INSD, 2020).

In the absence of reliable data, we assume low substitution elasticities between male and female labor by skill level, 0.5 for skilled workers and 0.7 for unskilled workers, reflecting the relatively rigid gender roles prevailing in the country (see Fofana, 2003; Fontana et al., 2020). For the values of variables and parameters related to the domestic sphere, which is not explicitly captured in the SAM, we draw on data from the national survey on institutions and gender equality in Burkina Faso (OECD-INSD-MFSNF, 2018). The data from this survey enabled us to determine the time that men and women devote to domestic activities. Given the lack of data on the maximum available time for work and leisure, we follow the calibration approach proposed by De Melo and Tarr (1992), assigning values to the income elasticity of labor supply and the Frisch parameter (set here at −0.2 for unskilled men and women, and −0.15 for skilled men and women and −1.5 for the Frisch parameter) to infer the necessary parameter values.[2]

2.4 Scenario of simulations

The model runs for the period 2018–2050. First, a "Business-as-Usual (BAU)" baseline scenario is simulated by updating the set of constant parameters and exogenous variables of the model from 1 year to the next. To do this, we chose the average annual growth rate of the Burkina Faso population.

In a second step, we simulate and present different scenarios of climate shocks in comparison with the baseline scenario. To introduce climate shocks into the CGE model, we modify the productivity parameter of the value added of the agricultural sectors. We rely on agronomic and economic studies in Burkina Faso to determine the level of the shock, and in the absence of information on a given crop, we resort to studies done in the West African context. We use forecasts of crop yield changes provided by general circulation models (GCMs) that simulate the effect of climate variables. Some existing studies do not rule out an increase in yields of some crops (see Liu et al. (2008) for rice and millet), but most predict a long-term decline in yields of major crops. The World Bank (2019) applied the International Model for Agricultural Commodity and Trade Policy Analysis (IMPACT) to Burkina Faso for the period 2018–2050 under various socioeconomic and representative carbon concentration scenarios (RCPs: RCP4.5, RCP6.0, and RCP8.5). The results show a negative impact of climate variability, with a yield decline in 2050 of 18–22% for maize, 1.99–3.77% for rainfed rice, 0.97–5.03% for millet, 7.46–9.32% for sorghum, 1.53–3.08% for other cereals, 3.92–4.53% for tubers, 8.87–9.73% for vegetables, 3.87–6.50% for cotton, 6.97–9.64% for oilseeds and 10.85–10.99% for fruits. Thornton et al. (2009) estimate that the decline in livestock yields in West Africa will be between 20.0 and 30.0% by 2050. Lam et al. (2012) estimate that the decline in fisheries yields in West Africa will be between 8.0 and 25.9% in 2050. Nelson et al. (2009) find that climate change reduces irrigated maize yields by 2–2.8% and irrigated rice by 14.4–18.5% in 2050.

To assess the impacts of climate change on agricultural productivity and the rest of the economy, we focus on 16 agricultural sectors in Burkina Faso. According to the impact assessment literature, agricultural productivity shocks vary according to the magnitude of the increase in temperature and the variability of rainfall. Based on this, two deterministic scenarios (mild and severe) were defined for the period 2018–2050 (see Table A in the Annex). To introduce the productivity shock into the model, we assume a continuous linear variation in crop yields. Thus, Table A in the Annex contains the annual rate of decline in yields of various crops from 2018 to 2050.

3 Results and discussion: long-run effects

The general equilibrium interactions in the model are complex; economic and social impacts are proportional to the magnitude of climate change, with effects gradually increasing over the period. We shall now proceed to an analysis of the final effect of the simulation at the end of the period (2050). Before delving into a detailed discussion of the results, we briefly indicate the transmission channel of the reduction in productivity of the agricultural sectors by 2050. A decline in agricultural productivity consequently has an adverse effect on agricultural production with the effects being transmitted to the other sectors of the economy through the supply of intermediate goods or the reallocation of production factors and to households through the increase in the prices of local goods.

3.1 Macroeconomic results

The results presented in Table 1 show that climate change has long-term adverse effects (2050) on macroeconomic indicators. These results are consistent with the findings of other CGE studies that assess the long-term impact of reduced crop yields due to global warming and rainfall variability such as those by Bosello et al. (2017), Calzadilla et al. (2013), Montaud et al. (2017), and Zidouemba (2017). Climate

2 Supplementary material presents the calibration of the various parameters of the domestic production equations.

TABLE 1 Impact of climate change on macroeconomic indicators (percentage change with respect to 2050).

MACROECONOMIC INDICATIORS	MILD SCENARIO	SEVERE SCENARIO
Real GDP at market price	−2.30	−7.24
Consumer price index	4.34	15.37
Real consumption of rural households	−0.75	−2.47
Real consumption of urban households	−3.15	−9.91
Total investment	2.20	8.24
Employment in market sector	0.84	2.06
Employment in the agricultural sector	3.14	6.12
Employment in the non-agricultural sector	−1.47	−2.00

Source: Simulation results.

change affects not only the sectors directly exposed, where production decreases significantly, but also those sectors not directly affected by the yield decline. The agricultural sectors directly affected by the drop in productivity due to climate change, as expected, see their production decrease and are forced to cut back on their intermediate consumption from unaffected sectors.

As a result, the reduction in output in all sectors has led most sectors, especially the agricultural sectors, to employ additional labor to compensate for the loss in productivity. This leads to an increase in total labor demand of 0.84% in the mild scenario and 2.06% in the severe scenario in 2050 in the market sectors. The increase in workers, especially in the agricultural sector, where the increases in the sectors most sensitive to climate change (maize, livestock, and forestry) range from 5.21 to 16.90% for the moderate scenario and from 22.22 to 33.70% for the severe climate change scenario. This increase in demand for labor in the agricultural sectors is largely favorable to unskilled workers. In the non-agricultural sectors, the reduction in production is accompanied by a decrease in employment. Indeed, the effects of climate change in the agricultural sectors have led to an increase in wage rates, especially the wage rates of unskilled workers. The increase in wage rates affects household income, as labor income is an important source of income.

Another transmission channel is derived from price changes in local markets. The decrease in production leads to a shortage of goods, mainly agricultural products, and consequently to an increase in the prices of final goods. This results in an increase in the consumer price index of 4.34% for the moderate scenario and 15.37% for the severe scenario. Indeed, the increase in local prices has negative effects on real household consumption, which decreases, affecting urban households more than rural households (−3.15% compared to −0.75% for the moderate scenario and −9.91% compared to −2.47% for the severe scenario) (Table 1).

Figure 1 highlights a substantial decline in the consumption of crop and livestock products across both rural and urban settings, particularly under the most severe scenarios. Urban households are disproportionately affected, with reductions exceeding 2% for rainfed crops such as maize and rice. In contrast, rural households experience smaller losses, and in some cases, even gains for irrigated crops, reflecting a relatively higher level of resilience. Traditional staples, including millet and fonio, register comparatively moderate decreases. The widening disparity between rural and urban areas underscores the urgency of targeted adaptation strategies, notably investments in irrigation infrastructure, support for climate-resilient local crops, and policies aimed at strengthening urban food security.

In addition, an increase in agricultural sector employment, the wage rate, and the rental price of capital positively affect the income of households, businesses, and the government, thus increasing their respective savings. This, in turn, leads to an increase in total investment of 2.20% for the mild scenario and 8.24% for the severe scenario.

In summary, with a decrease in real household consumption and a decrease in production across all sectors of the economy, climate change leads to a reduction in real gross domestic product in 2050 of 2.30% for a moderate scenario and 7.24% for a severe scenario. Our results are comparable to those found in the case of Burkina Faso by Zidouemba (2017) who reported a decrease in real GDP due to the effects of climate change on the agricultural sector.

3.2 Sectoral results

3.2.1 Agricultural sectors

As expected, the agricultural sector suffers the greatest adverse effects in selected climate change scenarios. At the national level, agricultural production decreases by 3.74% in a moderate climate shock scenario and by 8.07% in a severe climate change scenario. As shown in Figure 2, crop production, such as livestock, forestry and fisheries, fruits, oilseeds, irrigated rice, and other crops, suffers the greatest losses (over 10% for a severe shock). In terms of traditional production, maize, fonio, millet, tubers and pulses, which are less sensitive to climate change, show relatively smaller declines (less than 5%), while rainfed rice, sorghum, cotton and vegetable crops, which are moderately sensitive, decrease between 6.22 and 9.15% (Figure 2).

The reduction in agricultural production has consequences for employment in different agricultural sectors, given the variations in crop intensity in terms of capital or labor, as well as the intensity between different types of labor. In Burkina Faso, the agricultural sectors are labor intensive, particularly for unskilled labor. To compensate for productivity losses caused by climatic shocks, employment in the agricultural sectors is increasing. In fact, many agricultural sectors are hiring additional workers. Crops such as rainfed maize, irrigated rice, livestock, fisheries, and forestry, which are most sensitive to shocks and have suffered the greatest loss of production, increase their demand for employment more, varying between 5.21 and 16.90% for the light scenario and between 9.60 and 33.70% for the severe scenario. On the other hand, rainfed rice, fonio, and oilseed crops, which are less sensitive to climatic shocks, release workers following the drop in production.

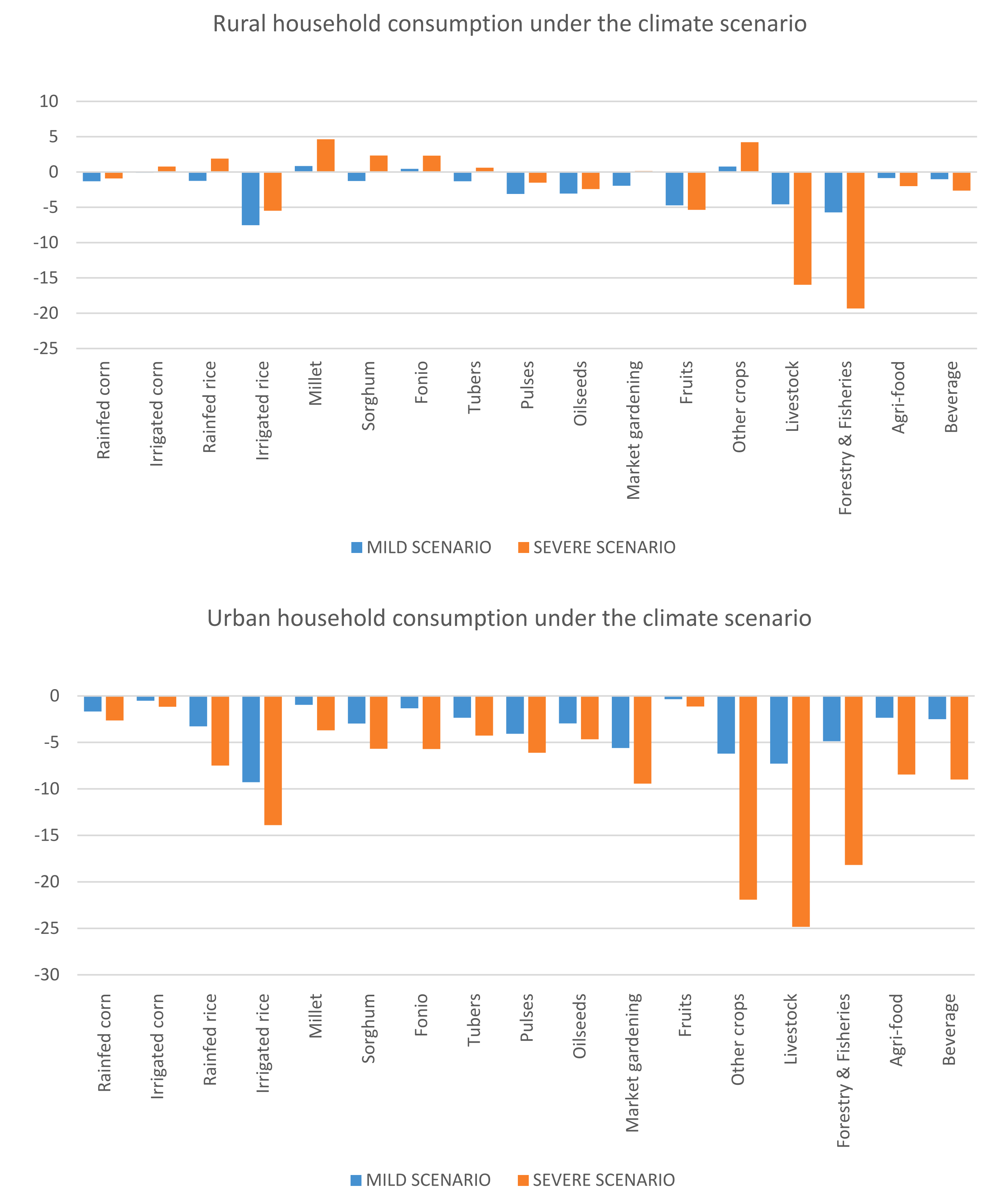

FIGURE 1
Impact of future climate shock on household consumption (in percentage change with respect to 2050). Source: Built by the authors with simulation results.

3.2.2 Nonagricultural sectors

The climate shock in the agricultural sectors is transmitted to the non-agricultural sectors through several channels, including the reallocation of production factors and the increase in the price of agricultural products. Indeed, the impact is negative for all nonagricultural sectors, with the most capital-intensive sectors experiencing the most significant declines. This is due to a decrease in intermediate demand resulting from the reduced production in the agricultural sector, leading to the releasing of workers from these dependent sectors, as well as a reduction in household consumption. The

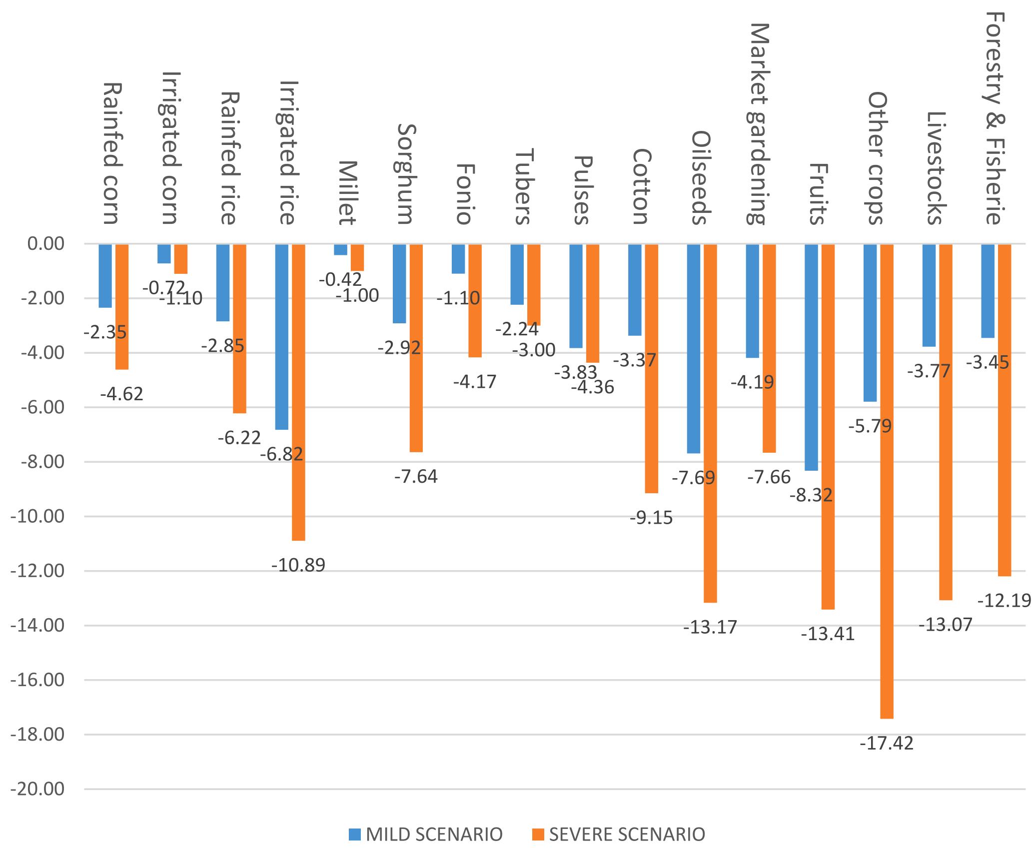

FIGURE 2
Impacts of climate change on agricultural production (in percentage change with respect to 2050). Source: Built by the authors with simulation results.

sectors that suffered the most were mining, food processing, manufacturing, hotels and restaurants, transport, telecommunications, business services, and chemicals, with production declines ranging from 6.08 to 13.83%. The chemical sector (which produces fertilizers and pesticides used in the agricultural sector) suffered the most at −13.83%. Other sectors, such as electricity, gas and water distribution, trade and repair, finance, textiles, real estate, construction, and public administration, experienced relatively smaller declines ranging from 2.73 to 5.90% with the sectors of electricity, gas and water distribution and trade and repair losing 5.90 and 5.60%, respectively, in terms of output.

The decline in production implies fewer workers in nonagricultural sectors, such as mining, agro-industry, chemical production and hotel and catering. These sectors suffer the largest declines, ranging from 4.94 to 11.44% under a severe climate shock scenario. They are highly dependent on the supply of agricultural products. The decline in agricultural production reduces the demand for intermediate inputs, thereby impacting sectors that are linked to agriculture (for example, agro-industry, chemical production and hotel and catering). Moreover, reduced household consumption, especially in urban areas, translates into lower demand, thereby impacting output in multiple sectors, more specifically, mining sector. These sectors will release workers. On the other hand, employment in the construction, trade and repair, telecommunications, finance and real estate sectors increased (ranging from 0.94 to 9.54% under the severe climate shock scenario, with the real estate sector seeing the largest increases at 9.54%), as these sectors are not as heavily dependent on local agricultural products, but rather on imported (mainly nonfood) products which have increased. However, the results show significant disparities by gender and the various types of labor.

3.2.3 Gendered effect of labor participation

In addition, the positive impacts on employment in the agricultural sector and negative impacts on employment in the non-agricultural sector described in Section 3.1 result in an overall increase in household participation rates in the formal labor market. However, there is an increase in participation in the agricultural labor market and a decrease in the non-agricultural formal labor market. Our results suggest that, in general, the increase in employment in the formal labor market leads to a reduction in domestic household workload in Burkina Faso. However, the increase in employment is mainly in the agricultural sector, and this employment is dominated by family labor. Additionally, the decline in participation in the formal labor market is observed in the industrial and service sectors, which offer better wages. Changes in employment in the formal labor market and domestic work are not uniform across to area of residence, gender, and qualification. Table 2 shows that rural women are most affected in the market sectors. In addition, skilled workers pay the highest price for the decline in formal participation in the labor market in rural areas. In the severe scenario, domestic burdens increase by 1.47% for unskilled women and by 3.91% for skilled women. In the same scenario, domestic burdens increase by 1.72% for unskilled men and by 3.24% for skilled men. In urban areas, on the other hand, the drop in productivity in the agricultural sector has a positive effect in terms of participation in the labor market and a

TABLE 2 Gendered impacts of climatic shock on labor participation by qualification and location (in percentage change with respect to 2050).

Areas	Gender	MILD SCENARIO				SEVERE SCENARIO			
		Unskilled		Skilled		Unskilled		Skilled	
		PAID	UNPAID	PAID	UNPAID	PAID	UNPAID	PAID	UNPAID
Rural	Female	−0.25	0.10	−1.47	0.90	−3.67	1.47	−6.00	3.91
	Male	0.21	−0.13	−0.50	0.66	−0.88	1.72	−2.06	3.24
Urban	Female	3.44	−1.29	0.56	−0.50	9.86	−3.69	1.51	−1.37
	Male	0.98	−1.52	0.29	−0.74	2.07	−3.46	0.77	−2.01

Source: Simulation results.

reduction in domestic burdens. Women in the trade and manufacturing sectors are the most favored by the increased demand for additional labor. Additionally, it is unskilled women and men who benefit the most from increased formal participation in the labor market.

As Table 2 shows, skilled women experience higher declines in market employment than unskilled women in rural areas, translating into a higher burden of domestic work for skilled women. Similarly, skilled men experience a greater increase in domestic work time than unskilled men in rural areas. The results show that rural areas are the most vulnerable to climate change, with skilled women in particular being the most affected.

3.3 Impact on agents

In both simulations (mild and severe), all agents are positively affected by 2050. Businesses derive their income mainly from the rent of capital, thus benefiting from the increase in the rental rate of capital in the agricultural and nonagricultural sectors. Similarly, the government derives its income from taxes on income and products, as well as from the rent of capital. These revenues increase in response to higher factor and product prices. In mild and severe scenarios, the effects follow the same trend, but with a small difference in magnitude. Business income increases by 0.65% in the mild scenario and by 2.78% in the severe scenario, while government income increases by 0.90% for a mild climate shock and by 3.98% for the severe scenario.

For households, like other agents, the impact is positive. The most positively impacted are rural households, but the effect is more pronounced in the severe scenario. Indeed, nominal income increases for all types of households because of an increase in wages in the agricultural crop sectors, which seek to offset the loss of productivity by asking for additional workers. In addition, the increase in the price of capital and transfers from other agents benefit households. Urban households experience a slight increase in income compared to rural households. Indeed, for the severe climate shock scenario, while income increases by 3.93% in urban areas, in rural areas it increases by 12.52%. However, given that the consumer price index has increased (see Table 1), real consumption falls for all households. Since urban households are highly dependent on the market for the supply of agricultural and food goods, their real consumption is falling more than that of rural households. As mentioned above, rural households are less affected due to their income from labor and capital, which increases in the agricultural sectors, and their low dependence on agricultural and food markets.

3.4 Impacts on poverty

Table 3 presents the long-term (2050) impact of climate shocks on poverty according to the gender of the head of household and the area of residence. In Burkina Faso, approximately 85.1% of households are led by men, of which 36.9% are in urban areas and 48.2% are in rural areas. For the reference year, the poverty rate is higher in male-headed households in both rural and urban areas. The previous section showed that climatic shocks in the agricultural sector led to an increase in the price of final goods and an increase in consumption expenditure. Thus, compared to the baseline situation, both scenarios lead to an increase in poverty, particularly in rural areas.

Furthermore, the gap in rural poverty rates between female and male-headed households remains large. Simulation results show that under a severe climate shock scenario, the incidence of poverty between 2018 and 2050 increases by 9.34% for male-headed rural households and by 8.47% for female-headed rural households. Additionally, there is an increase in the depth and severity of poverty. This could be unfavorable to women, as more than 52% of the members of both male- and female-headed households are women. Thus, the vulnerability of the poorest women is increasing.

3.5 Sensitivity analysis

In this section, we present a sensitivity analysis to perform a robustness check of our results. Previous CGE studies incorporate aspects of gender and endogenous labor supply in the labor market that are not common; therefore, a sensitivity analysis of our results is crucial. This analysis allows for variations in the values assigned to the parameters of labor demand and supply, as well as those related to the production and consumption of goods produced in the household.

Our labor market results are relatively sensitive to the income elasticities of labor supply and the elasticities of substitution between male and female labor for skilled and unskilled workers. Indeed, we note that the maximum time available for doing homework and paid work decreases for low labor elasticities and increases with high elasticities, but the simulation results do not change significantly. When we vary the substitution elasticity between men and women in the household production function, we find that the use of low elasticities has more negative effects on the economy. However, compared to the main scenario, the results of the simulations are almost unchanged.

Table 4 presents the results of macroeconomic variables (real GDP, real consumption, investment, consumer price index, and employment) of the ±20% variations applied jointly to the substitution elasticities between female and male (skilled and unskilled) labor in the production of market and household goods, the income elasticity of female and male (skilled and unskilled) labor supply of each household and the consumption elasticity of household goods. The results indicate a minor variation for the simulated climate shock scenarios, but these variations do not affect the observed trends in the key economic variables mentioned in Table 4. Therefore, we can conclude that the findings are robust, as the sensitivity analysis does not reveal a significant change. However, the use of low elasticities (especially on labor supply and demand) has more negative impacts on the economy compared to using higher elasticities which tend to reduce the negative effects. Finally, it would be relevant to use elasticity values that accurately reflect the labor market situation.

TABLE 3 Impact on poverty between 2018 and 2050.

Poverty Indicator	Baseline scenario (in %)	Simulation scenarios (changes in % from the base)	
		MILD SHOCK	SEVERE SHOCK
Rural Areas			
Men			
FGT0	51.4	3.11	9.34
FGT1	15.3	3.92	13.07
FGT2	6.2	4.84	16.13
Women			
FGT0	47.2	2.54	8.47
FGT1	16.3	3.07	10.43
FGT2	7.3	4.11	13.70
Urban Areas			
Men			
FGT0	13.2	4.55	14.39
FGT1	3.3	6.06	18.18
FGT2	1.2	8.33	25.00
Women			
FGT0	12.7	0.00	3.15
FGT1	3.4	5.88	14.71
FGT2	1.4	0.00	14.29

Headcount ratio (FGT0), poverty gap (FGT1), and poverty severity (FGT2). Abbreviations FGT, Foster–Greer–Thorbecke. Source: Calculations based on the microsimulation model.

4 Conclusion and policy implications

With the help of a carefully designed tool combining a sequential dynamic CGE model and a microsimulation model in a top-down approach, this study has identified the impacts of climate shocks on the agricultural sectors, women's employment and poverty in Burkina Faso by 2050 under a mild and a severe climate shock scenario. The results show that the reduction in agricultural crop yields by 2050 amplifies poverty and gender inequality to a large extent under a severe climate shock. Furthermore, the results reveal that future climate change impacts are highly detrimental to agricultural sectors, and these negative effects spill over into nonagricultural sectors. We find that households, particularly urban households, experience a sharp decline in real consumption, while rural households are the most threatened in terms of poverty, especially when the climate shock on the agricultural sectors is severe.

This article aims to contribute to the understanding of the links between climate change, domestic work, and paid work by explicitly incorporating domestic tasks performed by households in Burkina Faso by gender into a CGE model. Existing work (e.g., (Eastin, 2018; Goh, 2012; Rubiano-Matulevich and Viollaz, 2019) has shown that in developing countries women spend more time on domestic tasks than men. Our results reveal that the future effects of climate change would aggravate existing inequalities in the labor market, significantly reducing the amount of time women spend on paid work compared to men, especially in rural areas. This result shows that preexisting gender disparities in Burkina Faso would be exacerbated by the future effects of climate change, making women, particularly rural women in Burkina Faso, more vulnerable than men.

The results indicate that future climate change leads to a reduction in both agricultural and non-agricultural production, household consumption, and gross domestic product, which is consistent with the simulation results of Zidouemba (2017) and Cabral (2014) for Burkina Faso. Although using CGE modeling frameworks and approaches, our findings also align with those of other general equilibrium studies on extreme climate events, such as Montaud et al. (2017) on Niger, Montaud (2019) on Mali, Bosello et al. (2017) on Nigeria, and Cabral (2012) on Senegal. Furthermore, the results of our

TABLE 4 Results of sensitivity tests.

MACROECONOMIC INDICATORS	MILD SCENARIO		SEVERE SCENARIO	
	Low elasticities (−20%)	High Elasticities (+20%)	Low Elasticities (−20%)	High elasticities (+20%)
Real GDP at market price	−2.30	−2.30	−7.27	−7.20
Consumer price index	4.35	4.34	15.42	15.30
Real consumption of rural households	−0.76	−0.74	−2.52	−2.40
Real consumption of urban households	−3.14	−3.16	−9.90	−9.94
Total investment	2.20	2.20	8.26	8.22
Employment in the market sector	0.84	0.85	2.13	2.42

Source: Calculations based on the CGE model.

study are consistent with research emphasizing the need to incorporate vulnerability and gender inequality assessments in the context of climate change (Andersen et al., 2016; Eastin, 2018; Goh, 2012), and particularly with studies that highlight the importance of developing climate change adaptation strategies that also aim at poverty reduction (Abeysekara et al., 2023; Escalante and Maisonnave, 2022a, 2022b).

The main contribution of this study is to establish a link between the effects of climate change, gender, and poverty. However, it also has several limitations that open avenues for future research. First, the construction of the climate change scenario is based on changes in sectoral productivity. Future studies could broaden this approach by providing a more detailed analysis of the impacts of climate change in this country, taking into account changes in labor and land productivity, as well as the destruction of infrastructure. Second, the dynamic CGE framework adopted here is well suited to analyzing future climate shocks and understanding both first- and second-order effects on the overall economy. However, while Burkina Faso is frequently exposed to climate shocks, their intensity varies considerably from year to year. In this regard, incorporating elements such as the probability of occurrence of specific events, based on the country's past disaster history, would be relevant, particularly for ex-ante prevention efforts. Third, it should also be noted that this study does not incorporate adaptation policies. These aspects should be explored in future research to generate more comprehensive policy implications. Fourth, the model used in this study does not account for the structural regional heterogeneities of Burkina Faso, such as through the development of a multi-regional CGE framework. In this regard, disaggregating the model and its associated SAM by the country's main agro-climatic zones (Sahelian in the North, Sudan-Sahelian in the Center, and Sudanian in the South) would be particularly relevant. Such an approach would allow for a more accurate representation of regional specificities in terms of rainfall patterns, as well as the nature and performance of agricultural activities across these distinct zones. Finally, this study focuses on Burkina Faso, a country that shares several characteristics with other developing countries but also has important contextual specificities that contribute to theoretical insights. Future research could therefore explore the effects of climate-related disasters in other developing countries, particularly in West Africa, which share similar socioeconomic characteristics. This would allow us to assess the extent to which our findings are generalizable to other contexts. Moreover, the results could help guide adaptation strategies, by taking into account key elements of the Burkina Faso economy, such as the vulnerability of rural populations and gender inequalities. Indeed, the results show that simulated climate shocks can devastate the agricultural sector, compromising food security and poverty reduction. A key lesson from a public policy perspective is that the impacts of climate change on employment, food security and poverty vary according to skill level, geographic location, and gender. Unskilled women living in rural areas appear to be particularly vulnerable. These findings highlight the need to steer agricultural development and climate adaptation policies toward targeted investments and measures that take into account sector-specific characteristics and the needs of the most vulnerable populations. To mitigate the gendered impacts of climate change in Burkina Faso, several targeted actions are required.

- Improving women's access to climate-resilient agricultural technologies, irrigation, credit, and climate information is essential. This involves establishing government programs that provide direct subsidies or vouchers to women's agricultural cooperatives and individual female farmers to facilitate the acquisition of climate-adaptive technologies. These technologies include, in particular, drought-resistant seeds, improved traditional varieties, water-efficient equipment (such as drip irrigation systems, small-scale pumps, or rainwater harvesting devices), as well as improved storage infrastructure.
- Urban agriculture, where women play a key role, should be supported to enhance food security in cities. It would be appropriate to establish mechanisms that enable women's agricultural cooperatives and individual female farmers to access secure, long-term land leases or communal land use rights for urban plots. This could involve simplifying registration procedures or formalizing agreements with municipal authorities.
- Promoting traditional crops such as millet, sorghum, maize and fonio, more resilient and often cultivated by women can also help reduce vulnerability. It will consist in implementing programs aimed at ensuring that women farmers have access to certified, high-quality seeds of improved traditional crop varieties, either at subsidized prices or through voucher systems.
- Securing women's land rights and including them in local resource governance are fundamental. It is necessary to identify and amend the provisions in land laws, whether statutory or customary, that discriminate against women in matters of inheritance, acquisition, and control of land. In addition, social protection policies must be gender-responsive and adapted to climate shocks, particularly by supporting female-headed households. These measures, combined with better targeting of climate finance, would strengthen women's resilience to climate change and help reduce structural inequalities.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found at: https://zenodo.org/records/14782154; https://www.researchgate.net/publication/299468658_A_2005_Social_Accounting_Matrix_for_Burkina_Faso.

Author contributions

BS: Conceptualization, Data curation, Formal analysis, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. RM: Conceptualization, Formal analysis, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2025.1604950/full#supplementary-material

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Annex

TABLE A1 Main hypotheses for long-run scenarios of climate change for Burkina Faso (annual crop yield reduction rate in percentage over 2050).

CROPS	Mild	Severe
Rainfed corn	−0.50	−0.66
Irrigated corn	−0.06	−0.08
Rainfed rice	−0.06	−0.11
Irrigated rice	−0.44	−0.56
Millet	−0.03	−0.15
Sorghum	−0.22	−0.28
Fonio	−0.05	−0.09
Tubers	−0.12	−0.14
Pulses	−0.25	−0.29
Cotton	−0.12	−0.21
Oilseeds	−0.21	−0.29
Market gardening	−0.25	−0.29
Fruits	−0.29	−0.33
Other crops	−0.05	−0.09
Livestock	−0.24	−0.81
Forestry & Fisheries	−0.24	−0.81

Source: Author's calculation based on the works of Lam et al. (2012), Thornton et al. (2009), and World Bank (2019).