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Climate Change-Induced Heat Stress and Labour Reallocation in Burkina Faso: A CGE Analysis

Martial A. K. Houessou[1], Zuhal Elnour[1,2], Harald Grethe[1]

Correspondence to: Martial A.K. Houessou, martial.houessou@hu-berlin.de

[1]International Agricultural Trade and Development Group, Humboldt-Universität zu Berlin, Germany
[2]Agricultural Research Cooperation, Wad Madani, Sudan

Abstract

In Burkina Faso, the average temperature rises strongly, making it a hotspot for future climate-induced heat stress. High temperatures correlate with increased internal migration, with evidence of both rural-to-rural and rural-to-urban migration being observed. This trend will continue in a 2.5°C warming scenario by 2050. The locations where migrants are likely to relocate, considering climatic conditions and economic sectors, have not yet been investigated. We simulated these migration pathways using a general equilibrium model under a heat-induced labour productivity loss associated with a future +3°C global warming. Our findings suggest that heat-induced labour productivity loss would first harm the economy and reduce domestic production across sectors; subsequently, workers would react to the shock by relocating from the hotter Sahelian zone to other zones within agriculture. In the other sectors, workers would move into manufacturing and services. This evidence highlights the sectors and agroecological zones that require specific attention in response to climate migration.

Keywords: Labour migration; CGE; Global Warming; Burkina Faso; Household Welfare.

1. Introduction

Climatic variability and change are causing human displacement worldwide (Entwisle et al., 2020; Jacobson et al., 2019; Kaczan & Orgill-Meyer, 2020; Pradhan & Narayanan, 2022). This is taking the form of people moving from one region to another within a specific country (de Souza Ferreira Filho & Horridge, 2020), or from one country to another (Abbas et al., 2024; Chisari & Miller, 2016). Regions particularly vulnerable to these shifts include primarily sub-Saharan Africa, South Asia, and Latin America (Almulhim et al., 2024; Rigaud et al., 2018). Climate change-induced human migration is expected to continue in future global warming scenarios. For instance, in sub-Saharan Africa alone, a 2.5°C global warming scenario by 2050 could displace more than 70 million (over 50 million in West Africa) as a result of climate hazards (IPCC, 2022).

Burkina Faso is a West African and Sahelian country that is expected to be severely affected by climate migration in the future warming scenarios (IPCC 2022). The country experiences a generally hot and dry climate yearly (Tomalka et al. 2021). Annual average temperatures range from 25 to 32°C, with a monthly minimum temperature of 17°C in December and January, and a maximum temperature of 40°C between March and April (RCCC-ICRC,2024). The country is identified as a hotspot for future climate change-induced heat stress (Fotso-Nguemo et al. 2023). The country already exhibits intervillage migration associated with soil degradation (Sanfo et al., 2017) and rural-urban migration induced by low agricultural yields (Sawadogo et al., 2023). Consequently, the number of people displaced by climate-induced events continues to rise annually (Internal Displacement Monitoring Center 2024).

In future warming scenarios, climate change-induced migration is expected to increase in Burkina Faso. However, the destinations where migrants would relocate, considering suitable climatic conditions and economic sectors, have not been thoroughly investigated. We simulate these migration pathways using a static computable general equilibrium (CGE) model under a heat-induced labour productivity loss scenario of a future +3°C global warming. In the model, we incorporate a labour migration function that enables workers to respond to heat stress by moving between sectors and agroecological zones within agriculture.

Previous studies have examined the effects of climate change on labour migration through changes in agricultural yields (de Souza Ferreira Filho and Horridge 2020) and land availability (de Souza Ferreira Filho and Horridge 2020). However, did not consider human exposure to climate-induced heat as a push factor for labour migration. Despite conducting agriculture sector-specific analyses, these studies did not account for how heterogeneous climatic conditions within a country (as is the case in Burkina Faso) could influence labour migration patterns. We fill these gaps through two contributions. First, we assess the effects of climate change on migration through changes in workers' productivity induced by heat stress. Second, we employ a labour migration function in a static CGE model, which enables each labour type to migrate from one sector to another, excluding agriculture, and within agriculture across agroecological zones. The country is distinguished into three agroecological zones: (Sahelian, Sudano-Sahelian, and Sudanian), which exhibit heterogeneous climate conditions regarding rainfall and temperature. The Sahelian zone is arid and the hottest, with rainfall of less than 600 mm per year and approximately 100 days of temperatures exceeding 40°C annually (Alvar-Beltrán et al.,2020). The Sudano-Sahelian zone is semi-arid, with rainfall between 600 and 900 mm per year and 30 to 60 days of temperatures exceeding 40°C annually (Alvar-Beltrán et al.,2020). The Sudanian zone is the coolest, with rainfall exceeding 900 mm per year and temperatures of 40°C or higher for 1 to 6 days annually (Alvar-Beltrán et al. 2020). The specific labour migration in agriculture assumes that workers may be more productive or efficient in the least heat-affected agroecological zones than in others. As a result, agricultural outputs could be less affected in these cooler zones, attracting farmers to migrate there. According to Xu et al. (2020), this may be the only viable adaptation strategy if in-situ adaptation measures are unavailable in regions of origin. In the non-agricultural sectors, we expect workers to migrate in response to wage differences arising from heat-induced labour productivity losses.

The rest of the paper is presented as follows. Section 2 presents how labour migration can be modelled within a CGE framework. Section 3 presents the data, model, and simulation that are implemented. Section 4 presents the key results.

2. Modelling of labour migration in CGE models

In previous CGE studies, labour migration has been modelled differently, based on the objective. These works led to the establishment of labour migration functions that capture reallocation pathways between labour types across sectors (Flaig, Grethe and Mcdonald 2013; Mcdonald and Thierfelder 2009), countries (Agbahey, Siddig and Grethe 2018), regions within a country (de Souza Ferreira Filho and Horridge 2020), and rural-to-urban migration within a country (Sawadogo, Fofana and Maisonnave 2023).

Mcdonald and Thierfelder (2009) modelled labour migration between labour types based on response elasticities of supplying each labour type and the relative wage of migrants in their region of origin compared to the average wage level in all regions. In a practical sense, for the unskilled labour type, workers from any region can migrate to any other region, and vice versa. Flaig, Grethe and McDonald (2013) adapted the labour migration function from Mcdonald and Thierfelder (2009) by defining migration as bilateral between different sector blocks of specific labour types. This means migration is possible between the sector blocks, but only with a specific labour type. Similar to Mcdonald and Thierfelder (2009), migration from one sector to another occurs based on the relative wage, as well as changes in labour supply in the base situation. The so-called imperfect inter-sectoral labour reallocation function enables tracking the origin of a migrating worker. Agbahey, Siddig and Grethe (2018) built on Flaig, Grethe and McDonald (2013) work to examine the long-term effects of Palestinian labour mobility to Israel. They adapted the labour migration by Flaig, Grethe and McDonald (2013) to capture labour migration between sectors, irrespective of the labour type. This means that semi-skilled labour in agriculture can migrate into construction or manufacturing and work as unskilled labour. Additionally, they expanded labour migration outside domestic production, into Israel. In their extended model, labour migration from Palestine to Israel occurs based on the relative wage ratio in Palestine compared to the relative wage in Israel. The wage ratio is endogenous and first calculated in the model based on each country's labour wages, efficiency, and demand.

In addition to the previous considerations, labour migration functions were employed to assess the effects of climate change on labour migration flows within countries. de Souza Ferreira Filho and Horridge (2020) did this by incorporating an inter-regional labour migration function into a dynamic CGE model, known as TERM-MIG, for Brazil. They modelled climate change-induced inter-regional migration in Brazil based on the relative real wage between migrants' region of origin and destination. They set up the function to systematically account for all the labour types in the economy. In their labour migration function, they incorporated a constant that reflects historical data of net migration for each labour type and a variable that adjusts to keep national employment of each labour type at exogenous levels. They simulated two climate change scenarios (best and worst) based on changes in agricultural production and land availability by agricultural product and region in Brazil. Their results suggest that these climate change effects will induce a new migration pattern, redirecting unskilled agricultural workers towards some specific regions in Brazil. Sawadogo et al (2023) assessed the impacts of climate change through changes in agricultural yields on labour migration and women's poverty in Burkina Faso. They incorporated a rural-urban labour migration function into the PEP1-1 model, a static CGE model. Their function assumes lower wages in rural areas, predominantly agricultural, and higher wages in urban areas, predominantly non-agricultural. Thus, workers migrate from the rural agricultural sector to the urban non-agricultural sectors based on wage differences. In addition to wages, they assume that people migrate to urban areas in response to climate shocks, doing so with a minimal amount of capital. In their analysis, 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. Their results suggest pathways of rural-to-urban migration among workers in Burkina Faso.

In this study, we adapt the labour migration function by Agbahey, Siddig and Grethe (2018) and define migration within agriculture across agroecological zones and between sectors according to each labour type.

3. Methods

Our methodology consists of three key steps: first, we developed a new social accounting matrix (SAM) for Burkina Faso for 2019, disaggregating the labour market by skill level, agroecological zones, and categorize it by economic sectors; second, we run a heat stress-induced labour productivity shock considering a +3°C warming scenario using the STAGE-2 model by McDonald and Thierfelder (2015). We extended the STAGE 2 model, incorporating a labour migration function employed from Agbahey, Siddig and Grethe (2018); third, we analysed the labour productivity shock effects, accounting for workers' movement within agriculture across agroecological zones and between economic sectors in response to increased heat stress.

2.1. Data

We developed a Social Accounting Matrix (SAM) for Burkina Faso for 2019. It comprises 95 accounts, with 47 sectors producing 18 commodities. There are 14 agricultural activities in three agroecological zones producing 14 commodities, and two manufacturing (food and non-food) activities producing one manufacturing commodity. Mining, construction, and services produce one commodity each. The sectors employ 23 factors: land, capital, and 21 labour types. The labour types are distinguishable by their level of education (unskilled, semi-skilled and skilled), and economic sectors in which they are employed. Workers in agriculture are further disaggregated based on their agroecological zones of origin. Twelve household groups contribute to supplying these production factors domestically. These comprise rural-poor, rural-non-poor, urban-poor, and urban-non-poor households from the three agroecological zones. The rest of the accounts include government, enterprises, savings/investments, the rest of the world, indirect (production and sales) taxes, and direct taxes on income.

2.2. Model

We use an extended STAGE-2 model based on McDonald and Thierfelder (2015) incorporating a labour migration function, following on Agbahey, Siddig and Grethe (2018). The model operates under four main closure rules mimicking the fundamental characteristics of Burkina Faso’s economy. These include a fixed exchange rate and flexible foreign savings, investment-driven savings, fixed government expenditure, savings and flexible tax rates on household income, and fixed initial total factor supply fully absorbed by sectors through varying wage rates. For factor markets, we introduced two additional conditions: the labour supply in agriculture is the sum of all workers who migrate and those who remain in their agroecological zone of origin; each institution's initial total labour supply is the sum of migrants and non-migrants in each sector.

2.3. Simulations

We run a heat stress-induced labour productivity shock considering a +3°C global warming scenario and explore it under three labour migration scenarios. The first comprises farm labour movement across agroecological zones within agriculture in response to heat intensification under a +3°C global warming scenario. In the second scenario, we stimulate labour movement from one sector to another induced by heat intensification under the same warming scenario. The third scenario, more holistic, combines the first two scenarios. We isolate heat-induced labour migration impacts by comparing the climate change results against Burkina Faso’s economy in 2019, as depicted by the developed SAM.

4. Preliminary results

Our findings suggest that heat-induced labour productivity losses result in an economic downturn, reducing GDP by more than two digits. Besides, domestic production drops significantly, affecting all sectors, mainly mining and agriculture. As a result, trade is strongly affected by a decline in imports and exports. Overall, all households lose welfare, primarily the rural poor and non-poor. Households in the Sahelian zone experience the heaviest welfare loss. In response to the climate change shock, the labour movement within the farming sector occurs from the Sahelian zone to the other zones. Movement from other sectors predominantly occurs in manufacturing and services, where wage rates tend to increase. Our findings highlight the economic sectors and agroecological zones that require specific attention in response to climate migration in Burkina Faso.

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