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# Evaluating the regional impacts of climate change on women's well-being, domestic burdens and food security in Bolivia

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## Abstract

Throughout Bolivia, the degree of vulnerability amongst women and men to the impact of climate change is not equal. Indeed, vulnerability can vary due to regional and gender related differences, as well as varying levels of exposition to climatic events. Furthermore, this vulnerability may be exacerbated by increasing food insecurity due to climate change. This study uses a macro-micro model with a gender focus to assess the impact of climate change on food security and women poverty for Bolivia. We analyse a scenario in which specific regional damage occurs in the agricultural and livestock sector, as well as in the non-agricultural ones, due to adverse climatic events.

The simulation reveals negative impacts on the Bolivian economy, with the agricultural sector being the most affected. Food availability is reduced, which ultimately leads to greater food insecurity and food poverty with female-headed households suffering the most. The results also reveal negative effects on employment and increased domestic burdens, especially among women, which increases their vulnerability with women in the highlands being the most affected.

**Keywords:** Climate risk, General Equilibrium Model, Gender, Domestic work, Food security

**JEL:** Q54, C68, J16, Q18, O54

## 1. Introduction

Natural disasters such as floods, droughts and landslides make Bolivia a high-risk country in the context of climate change. The consequences of climate change are diverse, but most of them have negative impacts on the economy with the agricultural sector being the most affected. The Bolivian economy is based on the extraction of minerals and hydrocarbons and soya production. The agricultural sector accounts for about 30% of total employment (WDI, 2019). Therefore, given the importance of the agricultural sector and the strong role it plays in the generation of employment, the negative impacts of climate change on agricultural activities could generate substantial economic losses. However, due to Bolivia's geographical and cultural diversity, the nature of agricultural production and vulnerability to climate change varies from place to place. While the departments of Pando and Santa Cruz are distinguished by sophisticated and modern soybean production, which constitutes the bulk of the country's agricultural output, in the rest of the country, agricultural activity is more traditional, and does not produce high added value.

Climate change could affect agricultural productivity and threaten the food security of the poorest populations as well as increasing future health risks (Field et al., 2014). In Bolivia, low agricultural productivity, particularly in rural areas and rapid population growth could greatly increase the demand for food, affecting the capacity of local agricultural production to meet demands and jeopardising food security. In 2018, Bolivia's annual population growth rate of 1.4%, exceeded the Latin American average rate of 0.9% (WDI, 2018). The FAO statistics indicate, increases in agricultural and energy production as well as increases in protein production and food supplies over time. However, the amount of food produced per person in monetary value shows a downward trend since 2006, as does the amount of food provided per capita in kilocalories per day (Kcal). Ultimately, the number of malnourished people has not decreased since 2014, affecting about 2 million Bolivians (FAO, 2020).

Climate change affects men and women differently, with women being more vulnerable due to the fact that climate crises and disasters tend to have very negative impacts on gender equality (Eastin, 2018). In addition, trends such as the migration of men to non-agricultural activities means that climate-related damage affects women more so, due to the absence of men (Paudyal et al., 2019). In Bolivia, the effects of climate change in terms of poverty and inequality may vary significantly when taking gender and regional disparities into account. Indeed, the level of poverty is not the same, if one takes into consideration the gender of the household head or the region where the person is living. At the national level, women experience a higher rate of poverty (37.6%) than men (36.7%), experience (INE, 2019). At a regional level, the poverty gaps are even more striking. On the one hand, the highest levels of poverty are found in the departments of La Paz, Oruro and Potosí which are part of the highlands region, with poverty rates of 38%, 34% and 52% respectively. On the other hand, the lowest levels of poverty are found

in the departments of Santa Cruz and Pando, which are part of the lowlands region, with poverty rates of 26% and 32% respectively (INE, 2018).

With regard to inequality, Bolivia has been following a positive downward trend in income inequality, with the Gini index declining from 0.61 in 2000 to 0.42 in 2018. However, gender inequality remains high in the country. The gender inequality index has reached 0.45, while the average for Latin America is 0.39 (PNUD, 2015). The Global Gender Gap Index ranks Bolivia in eleventh place among 25 countries in the Latin American and Caribbean (LAC) region (World Economic Forum, 2020).

Gender inequality also extends to the labour market if we consider paid and unpaid activities. The percentage of Bolivian women participating in paid work is almost 20% lower than that for men (65.2% versus 82.6%) (WDI, 2019). Furthermore, Bolivian women are much more likely to work in jobs denominated as vulnerable by the World Bank (69.7% vs 58.7%) (WDI, 2018). In addition, women work in a narrow range of sectors. Accommodation and food services, education, health and social services and private household activities are the most female-labour intensive sectors (INE, 2018). In contrast however, if we focus on unpaid activities, women's participation rate far surpasses that of men. Women devote 23.5% of the daily 24 hours, doing unpaid household and care work, while men devote 12.6% of their time to this work (CEPAL, 2001). In addition, the domestic burdens and gender gaps are greater in rural areas, where women spend 7 hours a day on domestic chores compared to 1.4 hours for men (Ashwill et al., 2011). Therefore, the majority of domestic chores are carried out by women in Bolivia, as is often the case in developing countries (Rubiano-Matulevich & Viollaz, 2019). Consequently, the high burden of unpaid domestic work borne by women may explain why they participate less in the formal labour market, subsequently reducing their economic potential.

Gender inequality, mainly in the labour market, may be further worsened in the context of climate risk, since the effects of climate change are detrimental to gender equality mainly in agriculture-dependent and economically less developed countries (Eastin, 2018). In addition, the destruction of infrastructures could lead to longer journeys for women to fetch water and firewood, leaving them with less available time for paid work (Demetriades & Esplen, 2010).

In this paper we studied specific scenarios for three Bolivian regions (Highlands, Lowlands and Valleys) in order to analyse the impact of climate change on food availability, food security and food poverty. In addition, the study explicitly integrates domestic production with a focus on gender disparities, an approach that will provide a better understanding of the interactions between regional climatic shocks, women's domestic work, food poverty among women, and female food security.

The rest of the paper is organized as follows. The second section presents the literature review of the impacts of climate change on domestic work and food security. The third section describes the model and the data used to conduct this study. The fourth section presents all the results. Finally, the conclusions are presented in section five.

## 2. Literature review

In recent years, climate change has become increasingly visible worldwide. Although most studies agree on the vulnerability of the agricultural sector and the important challenges to be faced (Fischer et al., 2005; Galindo et al., 2014; Hertel & Rosch, 2010; Thurlow et al., 2009) some studies do in fact indicate beneficial impacts of climate change. For instance, in Canada, the growing season is expected to be longer, resulting in increased crop yields (Cabas et al., 2010; Cline, 2007). Due to the great diversity of economic, demographic and geographical conditions, the Latin American region may however not be affected by climate change in the same way (Field et al. 2014). Likewise, the impacts of climate change may also affect other areas, such as food availability or food security, which are linked to the dynamics of the agricultural sector. Academics and international organizations have estimated the future impacts of climate change on food security using a number of alternative models, including Computable General Equilibrium (CGE) models.

(Parry et al., 1999) examine global food security and estimate that climate change could increase the number of people at risk of hunger by about 80 million people by the year 2080. More specific studies covering different countries also reveal a variety of effects on food availability and food security due to climate change. In Guatemala, Vargas et al. (2018) use a static CGE model to simulate different climate change scenarios. Their results indicate that the resulting droughts and reduced agricultural productivity cause significant declines in crop and livestock production, and since agricultural production is essential to ensure food availability in Guatemala, the authors suggest that an appropriate regulatory framework for water distribution is needed. In Bolivia, studies examining the effects of climate change with CGE models are limited to the effects on agricultural productivity without addressing the food security dimension. For instance, Andersen et al. (2014), indicate that the direct and indirect effects of climate change affected agricultural productivity, generating significant losses. Aliaga & Aguilar (2009); Jemio et al. (2014) and Viscarra (2014) observe similar negative impacts on the economy, and more specifically on the agricultural sector.

Evidence suggests that the most vulnerable populations will be hardest hit by climate change and food insecurity (Björnberg & Hansson, 2013; Field et al., 2014; IPCC, 2014), and in particular, those populations already living in poverty, with female-headed households being more affected than male-headed ones (Denton, 2002; Goh, 2012; Lambrou & Piana, 2006; Quisumbing et al., 2018). There is a wide range of studies that follow a microeconomic approach, considering the gender dimension and including a focus on vulnerable groups in order to analyse the effects of climate change. For instance, in the town of Sonora in Mexico, Buechler (2009) states that agricultural activity can no longer be guaranteed there, due to rising temperatures, which will affect women and men to different degrees, undermining food security. McKune et al. (2015) report that

livestock keepers are experiencing increased food insecurity due to climate change and propose a gender-sensitive conceptual framework in order to understand and improve household food security. According to Alston (2014), it is essential to consider the gender dimension when analysing climate change because women play an important role in adapting to climate change. Yet, their ability to adapt to climate change is weaker than men's (Adzawla et al., 2019; Dey et al., 2018), meaning that ultimately, they are more vulnerable.

While there are several microeconomic studies that consider gender and the existence of vulnerable groups, gender-focused macroeconomic studies that provide analysis of the different impacts of climate change on the economy as a whole are scarce. For instance, Chitiga et al. (2019) use a dynamic CGE model to assess the impacts of climate change in South Africa from a gender perspective and find that unemployment amongst women increases more than that amongst men in the long term. Sassi & Cardaci (2013) use a CGE model to analyse the impact of climate change in Sudan. The authors report a reduction in the supply of cereal and an increase in prices that mainly affect the poorest people through dimensions such as food availability and access to food. Nevertheless, these studies, like all those cited above, focus on the market economy and overlook the non-commercial sphere, which according to the literature, is characterised by the significant amount of domestic chores, carried out mainly by women (Rubiano-Matulevich & Viollaz, 2019). Arora & Rada (2020) use a CGE model that integrates unpaid household tasks and leisure as goods produced within the household economy, in order to assess the effects of technological improvements in the household and agricultural sectors in Mozambique. The authors show that social norms interact with the allocation of labour and resources at the household level, severely limiting the benefits of technological improvements. Our study aims to fill the void in the existing literature on climate change studies that integrate domestic activities.

### **3. Methodological framework and data**

#### **3.1. The model**

To evaluate the regional impacts of climate change on women's domestic burdens, food security and poverty in Bolivia, we use a static CGE model based on the PEP 1-1 from Decaluwé et al. (2013), several assumptions of which we have changed in order to take into account the problems of our study. The production function of technology assumes constant returns to scale and producers have the possibility to sell their products either on the local market or on the international market. Production follows a Leontief-type function between value added and intermediate consumption at the top level and for each activity. Value added is a Constant Elasticity of Substitution (CES) type of function of composite labour and composite capital. Composite capital is a CES function between machineries and land. Composite labour is disaggregated according to skills levels following a CES function, and at the next level, each type of skills is further disaggregated between men and women. Following the pioneer work of Fontana & Wood (2000) and Fontana (2004), we have used the same value of elasticity of substitution (0.2), translating that men and women are not easily substitutable.

The model distinguishes four different institutions: households, firms, the government and the rest of the world. Households are broken down according to their location (highlands, valleys and lowlands) and also according to gender (male and female). This results in a total of 6 household categories. The model distinguishes three different sources of income for households: labour income, capital income and transfers from other agents.

Table 1 - Source of household income by gender and region (%)

Location	Gender	Source of income		
		Labour	Capital/Land	Transfers
<b>Highlands</b>	Male	87.20	0.74	12.06
	Female	77.90	0.65	21.45
<b>Valleys</b>	Male	81.19	1.50	17.31
	Female	66.58	1.26	32.16
<b>Lowlands</b>	Male	85.75	3.62	10.63
	Female	79.88	3.40	16.73
<b>National</b>	<b>Male</b>	<b>84.98</b>	<b>2.12</b>	<b>12.90</b>
	<b>Female</b>	<b>75.18</b>	<b>1.89</b>	<b>22.93</b>

Source: Own elaboration from the Social Accounting Matrix, 2012.

Bolivian household's income comes mainly from labour in all regions (Table 1). However, the share of this income source is more significant in male-headed households than in female-headed ones (84.98% vs. 75.18%). Additionally, in the valleys region, the share of income coming from labour is lower than for the other regions and notably for women. Transfers also constitute an important share of household income, especially in female-headed households in the highlands and valleys, where transfers represent 21% and 32% of total household income, respectively. Finally, households receive income from land which constitutes a part of the capital composite factor. Although this source represents the smallest share of total income (between 1% and 4%), it should be noted that households in the lowlands region and particularly those headed by men receive the largest share. Indeed, 52% of this income is received by men in the lowlands, followed by 17% for women in the same region.

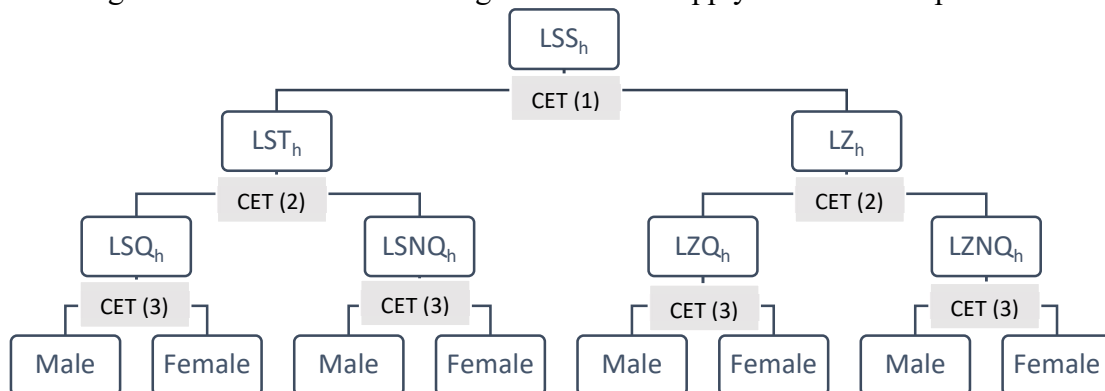
Households use their income for tax payments, savings, and mainly for consumption. Savings represent between 10% and 14% of total household budgets, with households in the valleys saving the most and those in the lowlands saving the least, especially female-headed households in this region, who allocate 0.3% less money to savings than their male counterparts.

Government collects indirect taxes (import duties, taxes on commodities and taxes on production) receives transfers from other agents and collects direct taxes from households and firms. More than 50 % of its income comes from indirect taxes. It mainly uses its income for public expenditure (mainly on non-tradable commodities) and for the payment of transfers to non-governmental agents. The remainder constitutes savings. Firms income comes from capital income (96.54%) and transfers from other institutions. They pay income taxes, dividends and transfers to other agents and the remaining income constitutes savings.

As we mention previously, our model assumes an endogenous labour supply that incorporates a gender dimension and a time constraint that depends not only on the amount of time that households allocate to their activities in the formal market, but also on household activities, following Fontana & Wood (2000) and Fofana et al. (2003). Based on Escalante & Maisonnave (2020), the amount of time spent on domestic tasks in Bolivia was determined using time-use surveys which indicate that women spend up to four times more time doing domestic chores than men (Canelas & Salazar, 2014; Lundvall et al., 2015). In addition, given the absence of time-use data per level of education, we used the Peruvian time allocation estimates from (Rubiano-Matulevich & Viollaz, 2019). Based on these studies, it was estimated that unskilled women allocate seven hours per day to domestic work, while skilled women allocate four and a half hours per day. Unskilled men, however, allocate only three hours to domestic chores, compared to one and a half hours for skilled men.

Figure 1 illustrates the structure of the endogenous labour supply. Technically, we assume that the total available labour supply, determined by households, presents a matching between the different types of labour through CET-type of functions at three levels. Firstly, between the formal labour market and the domestic labour market. Secondly according to the skill level, and thirdly according to gender. This means that male and female-headed households, whether skilled or unskilled, divide their time between commercial and domestic activities. In addition, it is considered difficult to transform or replace both skilled and unskilled workers as well as men and women within each skill level. Therefore, based on previous studies (Cockburn et al., 2007; Fontana, 2004; Fontana & Wood, 2000; Siddiqui, 2005), we reflect the rigidity of gender roles, setting the value of female/male transformation elasticities at a low value at all levels.

Figure 1: Structure of the endogenous labour supply and domestic production



Source: Own elaboration

Note:  $LSS_h$ =Total available labour supply,  $LST_h$ =Total available labour supply in formal labour market,  $LZ_h$ =Total available labour supply in domestic labour market,  $LSQ_h$ =Skilled labour supply formal market,  $LSNQ_h$ =Unskilled labour supply formal market,  $LZQ_h$ =Skilled labour supply domestic market,  $LZ<sub>h</sub>NQ<sub>h</sub>$ =Unskilled labour supply domestic market.

To assess food security in Bolivia under our climate change scenario, we adjusted the FAO indicators both in the absence and presence of climate change in Bolivia by making some changes based on the degree of regionalisation provided by the model. More specifically, our analysis addresses the dimensions of food availability and food access in Bolivia. On the one hand, food availability is measured by changes in agricultural production as well as by changes in the food supply for the local markets at the regional



level. On the other hand, food access is measured through variations in real household consumption of agricultural goods according to our climate change scenario. In addition, food access is studied at the regional level for both male- and female-headed households.

Finally, we linked our model with micro-simulations to assess the effects of climate change on food poverty in Bolivian households using a top-down approach. This means that once the CGE model is run, changes in the wage rate, income level and prices under the climate change scenario are transmitted to the micro (top-down) module. This module also integrates gender and regionally disaggregated data that will make it possible to estimate regional changes in food poverty among men and women.

### 3.2.Data

The main source of data comes from a Social Accounting Matrix (SAM). Specifically, we use the 2012 SAM developed by the IFPRI et al. (2018), which initially provided a breakdown of the agricultural sector into nine crops . The crops were aggregated into two groups representing two types of agriculture (traditional and modern). Likewise, a regional breakdown was carried out for both types of agriculture considering the three regions (highlands, valleys and lowlands) for the purpose of implementing our regional climate shocks. Thereby, three specific agricultural subsectors have been created: one for each region, considering both traditional and modern agriculture in each region.

The final model has 26 activities, nine of which are agricultural activities consisting of 3 different types of agricultures (traditional, modern, and livestock) for each of the three regions. The SAM also has 30 commodities, including nine agricultural goods: cereals, vegetables, tubers, fruits, other non-industrial agricultural activities, soya, sugar cane, coca and livestock. The land factor is broken down into the 3 regions (highlands, valleys and lowlands).

This study builds on Escalante & Maisonnave (2020) and extends it with a regional dimension for agricultural sectors. This extension is relevant because the use of agricultural production factors, whether in traditional or modern agriculture, as well as the type and destination of agricultural production vary greatly according to location (Table 2).

Table 2 - Regional agricultural production and factor intensity by type of agriculture (%)

Location	Type of agriculture	Production by region	Factor intensity			
			Skilled labour	Unskilled labour	Capital and land	Total
<b>Highlands</b>	Traditional	71.14	33.43	52.73	13.84	100.00
	Modern	9.28	41.67	47.98	10.35	100.00
	Livestock	19.58	43.65	39.64	16.71	100.00
	<b>Total agriculture</b>	<b>100.00</b>	<b>35.99</b>	<b>50.16</b>	<b>13.85</b>	<b>100.00</b>
<b>Valleys</b>	Traditional	52.87	24.63	55.51	19.86	100.00
	Modern	9.23	29.27	54.55	16.18	100.00
	Livestock	37.90	45.49	37.79	16.71	100.00
	<b>Total agriculture</b>	<b>100.00</b>	<b>31.65</b>	<b>49.88</b>	<b>18.47</b>	<b>100.00</b>
<b>Lowlands</b>	Traditional	27.06	32.67	41.95	25.38	100.00

Modern	46.81	18.52	10.48	70.99	100.00
Livestock	26.13	44.67	38.62	16.71	100.00
<b>Total agriculture</b>	<b>100.00</b>	<b>30.29</b>	<b>29.04</b>	<b>40.67</b>	<b>100.00</b>

Source: Own elaboration from the Social Accounting Matrix, 2012.

As can be seen in column 3 of table 2, there is considerable regional variability in the type of agricultural production. The highlands and valleys tend to have a more traditional agricultural production system, while modern agricultural production is predominant in the lowland areas. It should be noted that traditional agriculture in Bolivia is labour-intensive and based on indigenous knowledge and practices and includes the cultivation of cereals, legumes, tubers, fruits and other non-industrial crops, while modern agriculture is characterized by the integration of technology and includes the cultivation of crops such as soya, sugar cane and coca. In addition, columns 4 to 6 indicate the factor intensities by type and location of agricultural production (labour, capital and land). In general, Bolivian agriculture is labour-intensive in all regions, with unskilled labour being the main factor, but most notably in traditional agriculture. Skilled labour is only more predominantly used in the lowlands, with modern agricultural production being mostly capital and land intensive, at more than 70%.

Agricultural production mainly ends up on the national market. In fact, 88% is traded locally while the remaining 12% is exported. It should be noted that modern agricultural production is the most exported, with soya being the main export product. It is not surprising that the lowland region, with its modern agricultural production methods, accounts for 56% of total agricultural exports.

Together with the SAM, we borrow Armington elasticities from Sevillano Cordero (2012), and use income elasticity from Morales et al. (2017). The labour market and domestic labour elasticities are taken from Fontana (2004). Finally, for the microsimulation module, we use data from the National Household Survey (2018).

## 4. Results and findings

### 4.1. Simulation and closure rules

The climate scenario presented in this paper is based on a study conducted by the UDAPE on the damages that occurred in Bolivia due to adverse climatic events. This study considers an analysis of the 129 Bolivian municipalities declared in emergency in the period October 2013 and May 2014. During the analysis period, 52 municipalities were recorded as having floods, 27 as having hailstorms, 10 as having landslides, and 40 cases of mixed events between floods, hailstorms and landslides. The study assesses the multi-sectoral effects of adverse climate events, quantifying the damage and estimating losses in the social, infrastructure and economic sectors (UDAPE, 2015). Our simulation integrates damages caused to both agricultural and non-agricultural sectors based on this report and takes into account the variation of international prices due to climate change.

Agricultural damage was integrated into the model in a region-specific approach. To align the accounts in the SAM with the reported agricultural damages and losses given for agricultural products at the departmental level, we have aggregated the departments into three macro-regions (highlands, valleys and lowlands) and the products into three categories (traditional agriculture, modern agriculture and livestock). Agricultural

damage occurs mainly in the lowland region (Table 3), followed by the highlands region, but to a lesser extent, with damage to livestock happening mainly in the valleys.

Table 3 – Value of lost production in agricultural crops and livestock by region (in millions of Bolivianos)

	<b>Highlands</b>	<b>Valleys</b>	<b>Lowlands</b>	<b>Total</b>
<b>Traditional</b>	139.22	137.80	269.38	546.40
<b>Modern</b>	13.35	48.56	81.21	143.13
<b>Livestock</b>	0.03	359.39	0.00	359.42
<b>Agriculture and Livestock</b>	<b>152.61</b>	<b>545.75</b>	<b>350.59</b>	<b>1048.95</b>

Source: Authors, with information from the UDAPE (2013)

In the model, these losses were introduced in a sectoral way, affecting both the capital and land production factors. Based on these results, it was estimated that the damage caused, represented losses affecting the land and capital factors of the traditional agricultural sectors by 38.3%, 25.3% and 38.0% for the highland, valley and lowlands regions, respectively. Estimates of losses incurred by the modern agricultural sectors were 29.2%, 57.3% and 3.9% for the same three regions. Finally, losses in the livestock sector were estimated to be 0.02% in the highlands and 90% in the valleys.

Non-agricultural damage was integrated into the sectors that were affected by the adverse weather events that occurred between 2013 and 2014.

Table 4 – Value of lost production in the non-agricultural sectors (Millions of Bolivianos)

	<b>Damages</b>	<b>Losses</b>	<b>Total</b>
<b>Transport</b>	470.46	21.23	491.69
<b>Water and sanitation</b>	99.07	3.21	102.28
<b>Electricity</b>	5.99	1.55	7.54
<b>Telecommunications</b>	1.51	1.28	2.79
<b>Forestry and fishing</b>	0.00	37.40	37.40
<b>Health and social</b>	73.63	17.76	91.39
<b>Housing/construction</b>	229.58	0.77	230.35
<b>Non-farm sector</b>	<b>880.25</b>	<b>83.19</b>	<b>963.44</b>

Source: Authors, with information from UDAPE (2015)

Based on UDAPE (2015), we assumed that these sectors suffered from a decrease in their capital stock by 21.7% for the transport sector, 23% for electricity water and gas, 12.6%, for forestry and fishing, 18.6% for the construction and commercial and 10.1 for the social services sector.

The simulation also considers variations in the international prices of agricultural products due to climate change. Following Nelson et al. (2009), we consider a price increase of 15% for the livestock products and a 17% price increase for soybeans. Finally, an average price increase of 37% has been applied to the traditional Bolivian crop products, based on the price projections for traditional agricultural products such as rice, corn and wheat.

## 4.2. Macro results

Since the scenario, assesses the damage caused by adverse climatic events in both the agricultural and non-agricultural sectors, we expect negative repercussions on the economy overall and particularly on the agricultural sectors, as they receive the bulk of the damage. The results confirm our expectations with the resulting negative effects being transmitted to the Bolivian economy through different channels.

On the one hand, the simulation not only has a negative impact on those sectors directly exposed, where production is considerably diminished but also affects those sectors which were not initially and directly impacted. As a result, a decline in production is observed across most sectors of the Bolivian economy, resulting in a decline in the employment rate (-0.16%). The massive release of labour-seeking workers into the economy, mainly from the agricultural sectors, results in a decrease in wage rates, which may have negative effects on the labour income of households since it is their main source of income, but may positively impact firms, since hiring workers would be cheaper.

On the other hand, a second transmission channel is derived from the variation that occurs in local and international prices. At the local level, the decline in production leads to a shortage of products, particularly those agricultural, leading thus, to an increase in the prices of final goods. This results in a 6.62% increase in the price index. At the international level, given that the climate scenario includes an increase in the international prices of agricultural goods, the price of imported agricultural goods also increase. The conjunction of higher domestic and foreign prices has a negative impact on household consumption, which decrease significantly, affecting women more than men (-3.68% vs -3.51%). This channel could also result in some positive impacts. Indeed, with an increase in international prices, local agricultural producers may see an opportunity to export their production. However, given that agricultural production, factor intensity by type of agriculture, and the destination of production are different for each region, we expect to have varied effects. The effects on production and trade at both sectoral and regional levels are presented in Section 4.3. Despite incentives to increase agricultural production and exports by benefitting from the higher international prices, capital losses in both agricultural and non-agricultural sectors are proportionally greater. Consequently, with real consumption declining and production being adversely affected in most sectors of the economy, the impact on real GDP is also negative (-2.75%).

Table 5 – Macro-indicators (percentage change from base)

	<b>Simulation</b>
<b>Real GDP at basic prices</b>	-2.75
<b>Consumer price index</b>	6.62
<b>Real consumption budget of Male-headed households</b>	-3.51
<b>Real consumption budget of Female-headed households</b>	-3.68
<b>Total investment expenditures</b>	0.12
<b>Employment</b>	-0.16

Source: Authors' calculations.

### 4.3. Sectoral effects

As expected, The Bolivian agricultural sector suffers the greatest amount of damage under the climate scenario. The results confirm a sharp decline in agricultural production. At the national level, agricultural production declines by 15.84%. However, given that agricultural damage is variable from one region to another and integrated according to the type of agriculture practiced (livestock, traditional or modern), the severity of the impacts is considerably diverse. Indeed, traditional agriculture recorded the largest decline in production by 21.81%, followed by livestock production which declined by 10.17% and, to a lesser extent, modern agricultural production which declined by 7.31%.

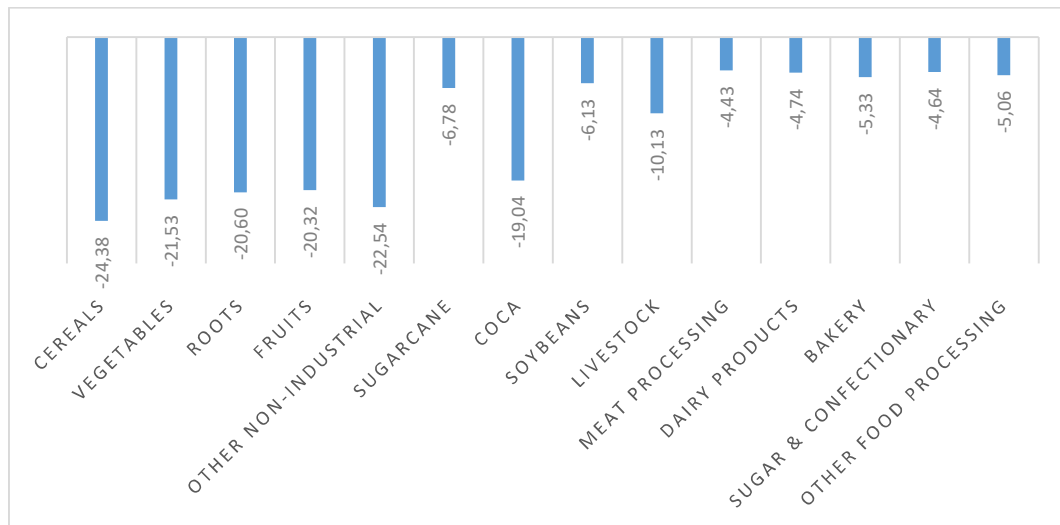
Moreover, in the highlands region, the decline in agricultural production mainly affects traditional crops. In the valleys, it is modern agricultural and livestock production that records the most significant losses. And finally, production in the lowland region, records the smallest losses with modern agricultural production being the least affected. This result reveals that modern agricultural production is generally less affected by climate change, with the lowlands region being the least affected region with a decline in production of only 3%. This result can be explained by the fact that, unlike the other Bolivian regions, modern agricultural production is predominantly practiced in the lowlands, accounting for almost 60% of total agricultural exports (see section 3.1).

For most of non-agricultural sectors, we observe as well a drop-in production, with the most significant declines occurs in the directly affected sectors (transport, electricity water and gas, forestry and fishing, construction, and commercial and social services). However significant declines also occur in the commercial and food industry, with the production of meat, milk and sugar being very exposed.

As mentioned above, production mainly declines in the agricultural sector and in the related sectors such as the food industry. Consequences on the availability of food on the local market can therefore be expected.

Figure 2 shows the supply of agricultural and food production for the domestic market per aggregate crops. There is a decrease in the domestic supply of agro-food. However, the supply of traditional crops has suffered the most significant decline (more than 20%), while modern crops has experienced the smallest losses, notably soybean and sugar, which have declined by 6.78% and 6.13% respectively. The supply of livestock products declines by 10.13%. Finally, in the processed food industry, the losses are the lowest observed (between 4 and 5%).

Figure 2: Supply of agricultural and food production for the domestic market (percentage change from base)



Source: Authors' calculations

In terms of exports, there is a sharp decline (-9.77%) in the agricultural and livestock sectors. However, the regional effects are quite interesting. The highlands region recorded the greatest decline (-21.24%), followed by the valleys region (-13.16%), and to a lesser extent, the lowlands region (-6.19%). Furthermore, exports of modern agricultural crops are less affected than traditional crop exports in all regions, while in the lowlands region, exports even increase by 4.49%. This may seem surprising, but it can be explained by the fact that increasing international market prices, stimulates agricultural sales abroad. In addition, as explained in section 3.1, the fact that modern agricultural production is predominant in the lowlands, accounting for almost 60% of total agricultural exports (based on soybean production), explains why modern agricultural exports from this region are increasing. As for non-agricultural exports, they increase in only 6 of 17 sectors, with exports from the oil, mining and machinery industries experiencing the greatest growth.

Regarding imports, the increase in international agricultural prices as a result of climate change makes it more expensive to consume imported products, thus imports should therefore decrease. However, the decline in production for the local market, and more specifically in agricultural and food production (see figure 2), creates a shortage in local food supply which, despite rising food prices, may be covered by an increase in imports, thus heightening the risk of food insecurity, as measured by the dependence on foreign imports (see figure 3). Sectoral level results suggest a declining trend in the importation of agricultural products, especially traditional products such as cereals, vegetables and fruit. However, imports from the livestock and food processing industries increase. With livestock, meat and milk imports increasing the most. Imports decrease however for the remaining non-agricultural sectors which are not related to the food industry.

As far as sectoral employment is concerned, the effects are generally negative. Indeed, declining production means that fewer workers are required to sustain production in each sector. Unsurprisingly, the most drastic declines occur in the agricultural sector, with employment in the traditional agricultural sectors being more affected than in the modern agricultural ones (-14.9% vs. -12.8%). Moreover, given that the Bolivian traditional agricultural sector, employs mainly unskilled workers (see Table 2), the effects of climate change will likely be more damaging to those unskilled. In non-agricultural sectors, there is a decline in employment in the non-agricultural sectors that have some links with the agricultural sectors (the food industry). For other sectors, there is a small increase in employment due to lower wage rates.

#### 4.4. Impact of gender on employment

As was explained in section 4.3, we found that the climate change scenario has negative impacts on employment. This is reflected in the lower labour market participation rates, particularly in the agricultural sectors. Despite the slight increase in employment observed in some of the non-agricultural sectors, the overall effect on employment is rather negative with an overall decline of 0.16% occurring. Consequently, the loss of formal market employment leads to an overall increase in the domestic workloads of Bolivian households by 1.11%. This change is not uniform across region and gender. Indeed, we find a decrease in employment and consequently, a 0.15% reduction in the formal participation rate for both men and women (Table 6). As expected, the loss of employment is accompanied by an increase in domestic workloads. However, although the reduction in formal employment is the same for both men and women, the increase in domestic burdens is greater for women than for men (1.30% vs. 1.05%). At the regional level, the disparities between men and women are even more pronounced. Reductions in formal market employment were observed in all regions, with women being more affected than their male counterparts in all regions except the highlands. Declining formal employment leads to an increase in the domestic burdens borne by women, causing profound damage to their wellbeing in all Bolivian regions. These findings indicate that climate change further increases the domestic burdens of female-headed households, though mainly in the valley and lowland regions.

Table 6 – Impact of climate change on formal and domestic employment by region and gender (percentage change from base)

<b>Location</b>	<b>Gender</b>	<b>Formal market</b>	<b>Domestic market</b>
<b>Highlands</b>	Male	-0.12	0.88
	Female	-0.08	1.08
<b>Valleys</b>	Male	-0.10	0.77
	Female	-0.12	1.24
<b>Lowlands</b>	Male	-0.22	1.37
	Female	-0.22	1.51
<b>Total</b>	<b>Male</b>	<b>-0.15</b>	<b>1.05</b>
	<b>Female</b>	<b>-0.15</b>	<b>1.30</b>

Source: Calculations based on the CGE model

The impacts are as well different according to skills levels (see Table 7). In fact, unskilled women experience greater declines in formal employment than skilled women in all regions, leading to heavier burdens of domestic tasks for unskilled women, with those women living in the highlands and valleys being the most affected. The fact that unskilled women are the most impacted comes as no surprise, since the greatest reductions that occur in employment, occur in the agricultural sector and particularly in the traditional agricultural sector which employs mainly unskilled workers.

Table 7 – Impact of climate change on the female labour market by region and skills (percentage change from base)

<b>Location</b>	Skilled female labour		Unskilled female labour	
	Formal market	Domestic market	Formal market	Domestic market
<b>Highlands</b>	-0.50	2.00	-2.92	2.73
<b>Valleys</b>	-0.54	2.17	-2.99	2.74
<b>Lowlands</b>	-0.75	2.97	-3.32	1.98
<b>Total</b>	<b>-0.61</b>	<b>2.42</b>	<b>-3.07</b>	<b>2.44</b>

Source: Calculations based on the CGE model

#### 4.5. Impact on agents

As explained in section 4.2, there is decline in wages and therefore a decline in the main source of household income. It should be noted that the decline in labour income is more significant among female-headed households than among male-headed ones. Nevertheless, the results also reveal an increase in income from capital and land as well as from transfers for all households. This can be explained in part by increases in the capital rental rates and particularly the land factor. In addition, the regional results indicate that the households located in the lowland regions benefit most from increases in capital and land income and are thus best able to compensate for their losses of labour income. This is to be expected since households in the lowland region, and particularly those headed by men, receive the largest share of total capital income (see Table 1). Overall, total disposable income for the majority of households increases by between 1% and 3%. Given the sharp increase in prices, households real consumption is decreasing with women in the highland region experience the largest declines in real consumption, while those in the lowland region are the least affected.

Government's income is decreasing by 0.44% mainly due to the drop in indirect taxes collected, and its income is dropping by 3.9%. For firms, given the increase in the rental rate of capital and land, their income is increasing by 4.36%, leading to an increase of its savings by 4.37%.

#### 4.6. Impact on food security and food poverty

In terms of food availability, the average agricultural and processed food production in Bolivia declines by 6%. Likewise, agricultural and food production for the domestic market declines for all agricultural products, with the supply of traditional products (-20%) experiencing the most drastic declines (see Figure 2). From a regional point of view, the results reveal that traditional agricultural in the highland and lowland

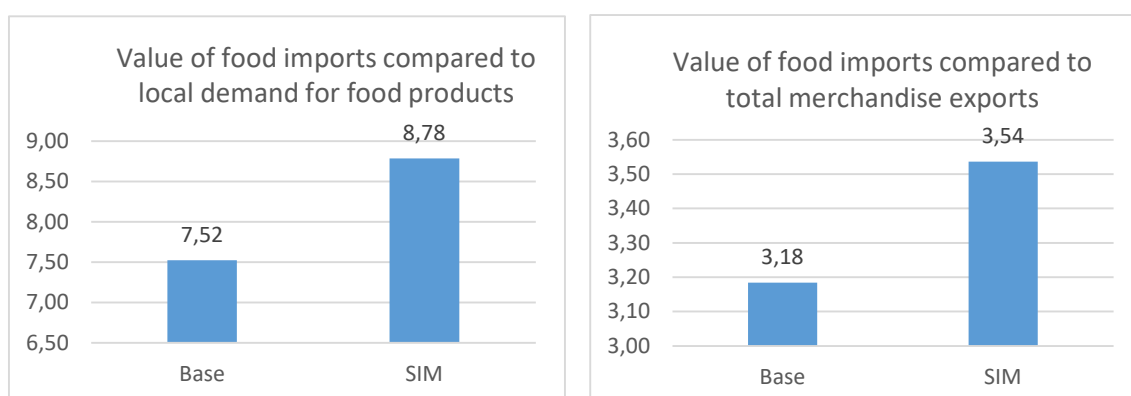


regions, records the largest declines in production, while in the valleys it is modern agricultural production that is most affected.

With regard to food access, our analysis is based on the evolution of real food consumption by Bolivian households. Once again, the results show negative impacts on all households. However, female-headed households experience greater declines in food consumption than male-head ones, particularly in the highlands region. Furthermore, it should be noted that the decline in food consumption is greater for traditional products such as cereals, fruit and vegetables.

Finally, with regard to food vulnerability, we analyse the evolution of indicators such as the food import dependency ratio and the value of food imports in relation to total exports. As can be seen in Figure 3, the results indicate that the value of food imports compared with the value of local food demand, increases by 1.26% with respect to the base scenario. Likewise, the value of food imports (excluding fish) relative to total merchandise exports, also shows a negative trend, increasing from 3.18% in the baseline year to 3.54% for the climate change scenario. The increase in this indicator is particularly negative as it captures the adequacy of foreign exchange reserves to pay for food imports.

Figure 3: Food security indicators (in percentage)

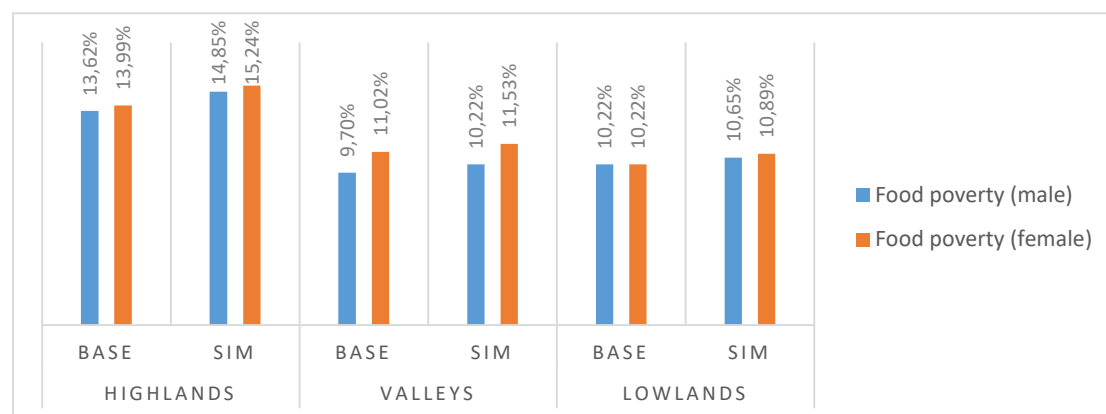


Source: Authors' calculations

Note: SIM = Climate change scenario, Base = Baseline scenario.

To evaluate the impact of climate change on the evolution of food poverty, we use the extreme poverty line as a food poverty baseline and from this we calculate the changes in the incidence of food poverty. As shown in Figure 4, the effects of the climate scenario on food poverty are quite interesting. Starting from the baseline scenario, it is evident that food poverty is higher among women than men in all regions. The highest levels of food poverty are observed for both men and women in the highlands region, though women are also more affected here than men. However, the results indicate the number of households experiencing food poverty is increasing. At the regional level, food poverty among men increases by 1.23%, 0.51% and 0.43% in the highlands, valleys and lowlands respectively. With regard to food poverty among women, the increases are more significant than for men, increasing by 1.25%, 0.50% and 0.67% for the same three regions. This ultimately leads to an increase in the number of women living in food poverty, with the highlands region being the most exposed with 15.24% of women falling into the food poverty trap.

Figure 4: Effects of the climate scenario on food poverty by region and gender type (in percentage)



Source: Calculations based on the Microsimulation model

Note: SIM = Climate change scenario, Base = Baseline scenario.

## 5. Concluding remarks and recommendations

The scenario analysed in this study helps us to comprehend the potential impacts of climate change on food security and women well-being in different regions for Bolivia.

The findings reveal negative impacts on the economy as a whole, with the agricultural sector being seriously affected with the effects spreading to many non-agricultural sectors. Furthermore, analysing the results by crop type and by region of production, reveal that the agricultural sectors more oriented towards traditional crops as well as the regions such as highlands, where traditional agricultural production is predominantly practiced are the most affected.

In the labour market, there are negative impacts on formal market employment, accompanied by increases in domestic burdens mainly in female-headed households which experience a much higher increase in their domestic burdens compared to men in all Bolivian regions.

Households are affected, with a significant decline in real consumption occurring, especially amongst female-headed households, where the decline is more severe than for male-headed ones. In addition, we found an interesting association between vulnerability according to the location of the household and the gender of the household-head. The consumption of traditional agricultural products sees the greatest decline and is highest in female-headed households, with those in the highland regions being the most affected. These results could affect the food security of Bolivia's most vulnerable citizens, particularly women, since the consumption of traditional foods such as cereals, vegetables and fruit constitute an important part of their daily diet.

Overall, the climate change scenario poses a considerable risk to food security, mainly due to the decrease in food production coupled with an increase in the relative price of nutrients. In addition, we find a reduction in the amount of locally available food and a greater dependence on the outside world for processed foods.

In addition, there is an increase in food poverty and once again, women are more affected than men. It is therefore clear that climate change is undermining the food security of the country with Bolivian women being most vulnerable.

Our results suggest that Bolivian women are a very vulnerable group in the midst of climate change and particularly those living in the highlands. We therefore believe that not only should any climate change mitigation policy be region-specific, it should also take into account gender and domestic activities and prioritise the nutritional needs of those most affected by food insecurity.

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