Assessing the impacts of climate change on women's poverty and domestic burdens: A Bolivian case study

Luis Escalante, Helene Maisonnave

Assessing the impacts of climate change on women's poverty and domestic burdens: A Bolivian case study

Luis Enrique Escalante[1] and Hélène Maisonnave[123]

Abstract

Climate change affects men and women differently and pre-existing gender disparities may be worsened. In Bolivia, high vulnerability levels and gender disparities exist in terms of education, access to employment, and poverty, making women a highly vulnerable population group. Our analysis uses a Computable General Equilibrium (CGE) model that explicitly incorporates household production with a gender focus, linked with micro-simulations to assess the effects of climate change on poverty and inequality in Bolivia. Two scenarios are evaluated. The first scenario refers to damages and losses of capital and land in the agricultural and livestock sector due to climatic events, while the second scenario analyses the decrease in agricultural production yields.

The simulations reveal that the climatic scenarios have negative impacts on the Bolivian economy, with the agricultural sector being the most affected. The results also reveal that climate change affects employment negatively in both simulations, and further increases the burden of domestic work, especially for women thus increasing their vulnerability. Furthermore, both simulations reveal negative impacts on poverty and inequality, with women being more affected than men. The results reveal that Bolivian women are more vulnerable to the impacts of climate change than men.

Keywords: CGE; Climate change; Gender; Unpaid work; Poverty; Latin America; Bolivia

JEL: C68, J16, Q54, O54

1. Introduction

Bolivia is considered to be one of the most vulnerable countries to adverse natural events in the South American region. In 2014, it was ranked eighth among the countries most affected by extreme weather events, while in 2013, the country was ranked 33rd (Kreft et al., 2016). Regarding natural events, Bolivia is mainly affected by floods and

[1] Le Havre University, Department of Economics, Normandy, France

[2] Corresponding author, helene.maisonnave@univ-lehavre.fr

[3] Partnership for Economic Policy (PEP), Nairoby, Kenya, www.pep-net.org

droughts. These events which occurred in 2013 and 2014, caused losses of approximately 3132 million BOB to the economy (or 405.50 million euros, applying the Boliviano/Euro conversion rate for the year 2014) and affected the lives more than 300 000 people (UDAPE, 2015). The agricultural sector is particularly important to the Bolivian economy as it accounts for 30% of the total employment in the country (ILOSTAT, 2019), however the sector has been particularly affected by these climatic events (Andersen et al., 2014).

Although Bolivia is known for its poverty and inequality, it is one of the countries that has reduced poverty by the greatest extent. Poverty had declined from 59.6% in 2005 to 34.6% of the population in 2018 (WDI, 2018). This poverty rate is still high, compared to the rates in neighbouring countries (CEPAL, 2019). In addition, Byerlee et al., (2005) note that poverty is mainly concentrated in rural areas where people earn their living from agriculture or related activities; this statement is valid for Bolivia, where according to (CEPAL, 2019), the highest levels of poverty are concentrated in the rural areas, with the indigenous population being more affected than the non-indigenous one (62% vs 48.2%). In urban areas, the poverty rate is 28.1% for the indigenous population and 22.5% for the non-indigenous one (CEPAL, 2019). The poor quality of existing infrastructure in rural areas (irrigation, water storage), makes these areas more vulnerable to the effects of climate change (Aswhill et al, 2011).

Poverty is not evenly distributed among men and women, with women experiencing a higher national poverty rate (37.6% vs. 36.7%, (INE, 2019)). Rural women are by far poorer than their urban counterparts (51.6% vs 31.7%, (INE, 2019)). In terms of inequality, Bolivia has been following the downward trend in gender inequality as observed in the Latin America region since 2000 (Klasen, 2020), with a Gini index dropping from 0.61 in 2000 to 0.42 in 2018.

However, gender disparities can be observed in education and in the labour market. Women have higher representation in basic education (no education, starting primary school and completion of primary school), while men have higher representation in higher education (starting secondary school, completion of high school, and superior studies) (INE, 2018). Additionally, the rural population has lower levels of education than the urban population (INE, 2018).

Gender biases is also apparent in the labour market, where women tend to be less active in formal economic activities. Women's labour force participation rate is lower than men's in the 15-64 age group (65.2% versus 82.6%) (WDI, 2019). Although the participation of women in the labour force in Bolivia is relatively higher than the Latin America and the Caribbean (LAC) region average (57.4%) (WDI, 2019), Bolivian women are much more likely than men 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. Indeed, the intensity of female labour surpasses that of male labour in only 7 out of the 21 sectors of the continuous employment survey, with accommodation and food services, education, health and social services, and private household activities being the most intensive sectors for women (INE, 2018). In contrast however, in the non-commercial sphere, women's participation far surpasses that of men. In fact, if we look at the employment status by gender type, we have two categories of unpaid work that are highly intensive in female labour: family worker or unpaid apprentice (66.1%) and household employee (95%) (INE, 2018). Likewise, the poorest women do the most unpaid work.

In Bolivia, as pointed out by Rubiano-Matulevich and Viollaz (2019) for different countries, women's participation in unpaid activities is greater than that of men. In addition, the poorer the household, the greater is the time devoted to these unpaid activities. Women devote 23.5% of the daily 24 hours, doing unpaid household and care work, while men devote only 12.6% of their time to this work (CEPAL, 2001). In rural areas, the difference is even more striking with women spending 7 hours per day on domestic chores compared to 1.4 hours for men (Ashwill et al., 2011). The high domestic workload of women results in them participating less in the formal labour market which reduces their economic potential.

This situation could be worsened with climate change. The agricultural and livestock sectors could experience the most severe impacts, but imbalances in the labour market could also be generated, threatening the well-being of the most vulnerable workers. Moreover, climate change could further impact women, with the destruction of infrastructures leading to a longer walks to fetch water and firewood, women may have less available time for paid work (Demetriades and Esplen, 2010). In addition, climate shocks and disasters tend to have a largely negative impact on gender equality (Eastin, 2018). The effects appear to be greater in countries that are relatively less-democratic, more dependent on agriculture and less economically developed than others (Eastin, 2018).

This study aims to analyse the effects of climate change on poverty in Bolivia from a gender perspective. To achieve this, we use a Computable General Equilibrium model that integrates domestic work and which is also linked to a microsimulation module. A CGE model is the most suitable tool for this work, as it makes it possible to analyse the impact of macroeconomic shocks on the different sectors of the economy as well as on agents, especially women. The remainder of the paper is organised as follows. The second section presents the literature review of the impacts of climate change on agriculture, poverty and the modelling of domestic work. The third section discusses the methodological framework and the data used to conduct this study. The fourth section presents the scenarios of the study and the results. Finally, section five summarises the main findings and proposes some policy recommendations.

2. Literature review

Many studies evaluate the impacts of climate change on economic activities, pointing out the vulnerability of the agricultural sector (Fischer et al., 2005; Galindo et al., 2014; Hertel and Rosch, 2010; Thurlow et al., 2009). Field et al. (2014) argue that the effects on agriculture would be very diverse due to the great diversity of economic, demographic and geographical characteristics of the LAC countries. The authors conclude that productivity in Central America could be reduced over the next 15 years, while in South America it could be maintained or even increased. More specific studies for the different countries in the LAC region also report a variety of effects (Ponce et al., 2014; Vargas et al., 2018). In the specific case of Bolivia, few studies assess the impact of climate change on the economy. Andersen et al. (2014), indicate that the direct and indirect effects of climate change affected agricultural productivity, generating significant losses. Aliaga and Aguilar (2009); Jemio et al. (2014) and Viscarra (2014) find similar negative impacts on the economy and specifically on the agricultural sector. However, none of the above studies take into account the impacts of climate change on population groups, and specifically on vulnerable ones.

There is evidence, that the most vulnerable populations will be hardest hit by the effects of climate change ((Bjornberg and Hansson, 2013; Field et al., 2014; IPCC, 2014). Castells-Quintana et al., (2018), examine climate change adaptation from the perspective of poor households. The authors indicate that successful adaptation requires taking into account the broader socio-economic trends that are occurring in many developing countries (such as population growth and urbanisation). Among the poor, men and women will be affected differently, with women suffering the most (Denton, 2002; Goh, 2012; Lambrou and Piana, 2006; Quisumbing et al., 2018).

For instance, Adzawla and Kane, (2019) found that climate change has substantially widened the gender welfare gap in northern Ghana. In the same region, Adzawla et al. (2019) find that the ability of women to adapt to climate change is weaker than men's. Dey et al. (2018) highlight the important role of women in the area of climate change adaptation but also their high degree of vulnerability.

In Latin America, some studies address the effects of climate change from a gender perspective. In Mexico, Buechler (2009) states that agricultural activity and particularly fruit production can no longer be assured in the Sonora area due to warmer temperatures. This change will affect women and men to different degrees, affecting the control they have over their livelihoods and food security. Andersen et al., (2017) analyse gender differences to vulnerability and resilience to shocks in Peru, Brazil and Mexico, including climate change and climate variability. The authors indicate that female-headed households in the three countries tend to be less vulnerable and more resilient than male-headed households. We feel that there is a need to take into account the gender dimension when analysing climate change (Alston, 2014). However, most of the studies that take the gender dimension into account are micro studies and therefore cannot capture the different impacts of climate change on the whole economy. Indeed, gender-focused macroeconomic studies that provide comprehensive analyses of climate change in specific economies are scarce. For instance, Chitiga et al. (2019) evaluate the impacts of climate change on South African women and find that unemployment amongst women increases more than that amongst men in the long term. However, their study focusses on the market economy and they omit the domestic market. Indeed, women are likely to suffer more from the effects of climate change given the resulting increase in domestic chores.

Due to climate-related damages, women may need to devote more time fetching water and firewood or allocate additional time to other domestic chores when their husbands have had to leave to try and find work elsewhere (Demetriades and Esplen, 2010; Paudyal et al., 2019). The additional time spent on domestic chores will further distance women from paid activities, increasing their vulnerability. Therefore, including domestic work in a macro model in the context of climate change is highly relevant. Integrating domestic work into studies was pioneered by Fontana and Wood (2000) and followed by Fontana, (2004), Cockburn et al. (2007) and Siddiqui, (2005), to analyse the impacts of trade liberalisation through a « gender lens ». As yet, there have been no studies analysing the effects of climate change on the paid and unpaid activities of men and women. Our study therefore fills a void in the literature on the effects of climate change by taking a gender approach and incorporating domestic activities into the model. Furthermore, in order to capture the effects on household poverty, we couple our macro model with a poverty study.

3. Methodological framework and data

3.1. The CGE model

To evaluate the impacts of climate change on women's poverty, we use the static Partnership for Economic Policy (PEP 1-1) standard model by Decaluwé et al. (2013).

In line with the Social Accounting Matrix (SAM), the model has 20 activities and commodities. The production function technology presupposes constant returns to scale presented in a four-level production process. At the first level, for each activity, production is a Leontief type of function of value added and intermediate consumption. At the second level, we assume that composite labour can be substituted with capital following a Constant Elasticity of Substitution (CES) type of function. Labour is further disaggregated between skilled and unskilled. Therefore, at the fourth level and for each skill category, the labour demand is a CES function between male and female workers, with an elasticity of substitution of 0.2. Female and male labour cannot therefore be easily interchanged. This assumes, implicitly, that there is a gender specialisation or division of the labour market in Bolivia.

The model distinguishes four different institutions: households, firms, the government and the rest of the world. Households are also disaggregated by gender and location: male-headed households in the rural and urban areas and female-headed households in the rural and urban areas. The model distinguishes three different sources of income for households: labour income, capital income and transfers from other agents. The income of male-headed households comes mainly from labour in both rural (89%) and urban (84%) areas. In female-headed households, income from labour is also the main source of revenue, but to a lesser extent than that of male-headed households. (77% and 75% in both rural and urban areas respectively). Transfers also constitute an important part of household income, mainly in female-headed households where transfers account for 22% and 23% of income in both rural and urban areas respectively, while in male-headed households transfers account for only 10% and 13% of income in rural and urban areas respectively. Finally, households receive income from capital and land. Although this source accounts for the smallest share of total income, it should be noted that urban households receive the biggest share: more than 90% of this income is earned by urban households.

All categories of households use their income for tax payments, savings, and mainly for consumption which is specified with a linear expenditure system (LES) type of function (Stone, 1954). There are interesting differences with regards to final consumption, which is the main household expenditure. In male-headed households, the proportion of consumption expenditure is slightly higher than that of women. However, if only the consumption of goods in the agricultural and livestock sector is considered, it is women who spend most, in both rural and urban areas. Rural households spend a larger proportion of their income on consumption compared to urban ones (92% vs 88%). Finally, savings account for between 8% and 13% of total household income, with urban households making the most (12.4% in male-headed households, 12.7% in female-headed households).

Firms' income is based on transfers from other institutions and mainly on capital income. They pay income taxes, dividends and the remaining income constitutes firms' savings. The Government collects direct taxes from households and firms and indirect taxes (import duties, taxes on commodities and taxes on production) and receives transfers from other agents. These resources are used for public expenditure (mainly on non-tradable commodities) and for the payment of transfers to non-governmental agents. The remainder constitutes savings.

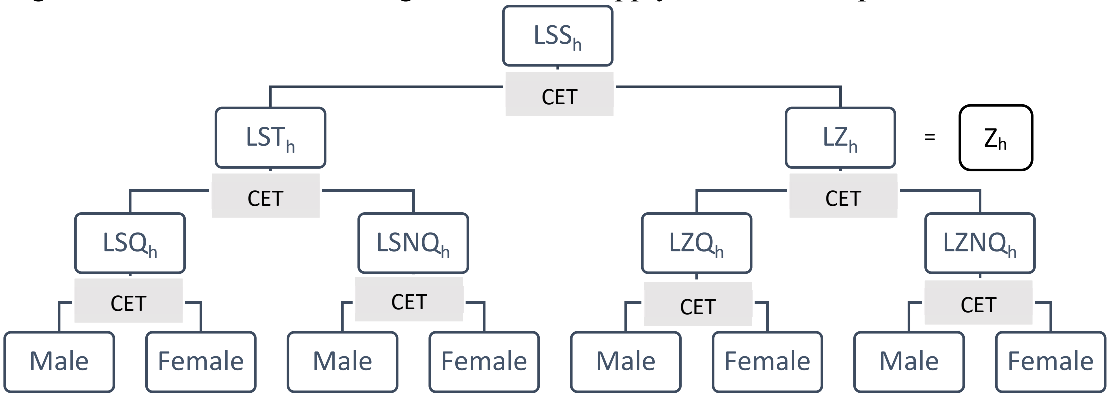
As already mentioned in the introduction, Bolivian women allocate a lot of time to domestic activities which prevents them from earning money. Following Fofana et al. (2003), we assume that men and women, whether skilled or unskilled, divide their time between domestic activities (taking care of the kids, fetching water etc.) and market activities. The allocation of time between the two activities is different for both men and women, but it also depends on whether they are skilled or not. Canelas and Salazar (2014) and Lundvall et al. (2015) determine that women spend up to 4 times more time on domestic duties than their male counterparts.

To complete the allocation estimates on the use of time and given to the absence of disaggregated data per level of qualification in Bolivia, we used estimates for Peru from Rubiano-Matulevich and Viollaz (2019). Peru is a country with similar characteristics to Bolivia in terms of skill-based domestic work. It was estimated that unskilled women allocate seven hours per day for domestic work while skilled women allocate four and a half hours. Unskilled men allocate three hours per day for domestic duties while skilled men allocate only one and a half hours.

This time devoted to this domestic production creates a new commodity which is made up only by labour and fully consumed by households. The value of domestic-produced commodities is equal to the value of the labour used in their production, where non-market labour is priced at its opportunity cost, as measured by the market wage rates. Technically, we assume that the total available labour supply, determined by households presents a matching between the different types of labour through a CET-type of functions at three levels. At the first level, between the formal labour market and the domestic labour market. At the second level, supply functions are also adapted according to the skill levels (skilled and unskilled) of both the formal and domestic labour markets.

Finally, at the third level and for each skill category, the labour supply is a gender-specific CET function with very low transformation elasticities for both skilled and unskilled workers (0.5 and 0.8 respectively). Figure 1 illustrates the schema of the endogenous labour supply according to the three levels as previously described. It should also be noted that unlike production in the formal market, we assume that domestic production does not require intermediate goods or capital and is performed only by a labour factor. Thus, the available labour supply in the domestic market (LZ_h) is in turn equal to domestic production (Z_h).

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



Source: Own elaboration

Note: LSS=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, $LZNQ_h$=Unskilled labour supply domestic market, Z_h=Domestic production.

To assess the impacts of climate change on gender poverty and inequality, we use a top-down approach. Specifically, once the CGE model is run, changes in the wage rate, income level and prices under climate change scenarios are transmitted to the micro (top-down) module to calculate changes in poverty and monetary inequality. In particular, we compute the FGT indicators from Foster et al. (1984) together with the Gini index for inequality.

3.2. Data

The SAM is based on IFPRI et al. (2018). It has 20 activities/commodities, nine of which are agricultural activities: cereals, vegetables, tubers, fruit, other non-industrial agriculture, soybeans, sugar cane, coca and livestock. In order to implement our climate shocks, we have grouped these 9 agricultural categories into two types of agriculture (traditional and modern), thus creating two specific agricultural sub-sectors: an agricultural sector of traditional products, and an agricultural sector of modern products. Traditional agriculture is labour-intensive and based on indigenous knowledge and practices, which have been developed over several generations. In the model, this type of agriculture includes the cultivation of cereals, legumes, tubers, fruits and other non-industrial crops. Modern agriculture is however characterized by the integration of technology and includes the cultivation of crops such as soybeans, sugar cane and coca. Likewise, Bolivian agricultural production is mainly destined for the local market. In fact only 12% of agricultural production is exported. Modern crops are however exported more than traditional crops (58% vs. 42%). Soybeans are the main agricultural export product (46% of total agricultural exports), followed by cereals, which make up 25% of total agricultural exports.

The SAM distinguishes three factors of production: capital, land and labour. Land is disaggregated into 3 regions (highlands, valleys and lowlands), and labour is disaggregated according to the level of skills (skilled and unskilled) and gender type. There are four different institutional accounts: firms, government, the rest of the world and households. The latter is further disaggregated according to household characteristics (rural and non-rural households for female-headed and male-headed households).

Next to the SAM, we use income elasticity from Morales et al. (2017) and borrow the Armington elasticities from Sevillano Cordero (2012). To assess the impacts on poverty and inequality, we use data from the National Household Survey (INE, 2018b).

4. Simulations and results

The first simulation is based on an analysis of the direct and indirect effects of the adverse weather events that occurred in 2013 and 2014 in Bolivia. It considers damage and losses due to climate events in the agriculture sector to be 689.53 million bolivianos (Design et al. 2017). It was estimated that the damage caused, represents losses affecting the land and capital factor of the agricultural sector by 21.9%. This simulation also considers the variation in the international prices of agricultural products due to climate change. We use the study carried out by Nelson et al., (2009), which gives forecasts for some agricultural and livestock products for the years between 2000 and 2050 using the NCAR (National Center for Atmospheric Research) model based on the A2 scenario of the IPCC (Intergovernmental Panel on Climate Change) report. We consider a price increase of 15% for products from the livestock sector and consider a price increase of 17% for soybeans. This price increase has also been applied to coca and sugar crops in Bolivia, because we consider that these are modern agricultural products. We then calculated an average price variation for the more traditional agricultural products such as rice, corn and wheat. An average price increase of 37% was estimated and applied to the Bolivian traditional crop products.

In the second simulation, we analysed the reduction in agricultural productivity due to climate change. For this, we use data from Viscarra et al. (2018), who estimate the impacts of climate change on the average yields of certain products for different scenarios in Bolivia. In particular, we take into consideration the impacts corresponding to the IPCC A2 scenario, where an estimated 5% drop in the average yield of soybean production and a 12% drop in the average yields of maize and rice in Bolivia will occur. In the model, we apply the variations in soybean yields to modern crops and the variations in maize and rice yields to traditional crops. Finally, as was the case in the first simulation, this one also takes into account the variation in international prices of agricultural products due to climate change.

4.1. Macro results

Given the importance of agricultural sector in Bolivia, negative results are expected for the economy as a whole, since the scenarios analysed in this study include damage to capital and agricultural land (first simulation), and a decline in agricultural productivity (second simulation).

The results confirm our expectations with a variety of negative effects, particularly in the agricultural sector. However, the effects are transmitted to the whole economy through different channels. On the one hand, damage to both capital and agricultural productivity not only has negative effects on agricultural production, which is considerably reduced, but it also affects other sectors. As a result, employment is reduced by 0.15% in the first simulation and by 0.02% in the second one. In the first simulation, agricultural employment is severely affected, and particularly concerning unskilled employment, owing to the high intensive use of unskilled labour in the cultivation of most agricultural crops in Bolivia. However, in the second simulation, losses in agricultural productivity are compensated for by increased working hours and therefore increased employment across most cultures. This explains the variations we observe in wage rates that decrease in the first scenario in greater proportions for unskilled workers, but increase in the second one, driven by the agricultural crop sector that seeks to attract more workers by pushing for a short-term wage increase. Regarding the capital rental rate, it increases in the agricultural sector due to higher use but decreases in the non-agricultural sectors.

On the other hand, we have a second transmission channel resulting from the increase in international agriculture and livestock prices as a consequence of climate change that is included in both scenarios. As a result, the price of imported agricultural goods becomes more expensive and this causes negative impacts on household consumption. Indeed, real household consumption decreases by 3.69% and 0.56% for the first and second simulations, respectively, due in part to the increase in international agricultural and livestock prices, but also due to the reduction in agricultural production that makes goods more expensive to purchase. This causes the price index to increase by 3.90% in the first simulation and by 3.14% in the second one. However, this channel also allows us to observe some positive effects. Indeed, with the increase in international prices, agricultural producers see an incentive to export their production. This explains why agricultural crops are affected differently. In section 4.2 we will present the effects on sectoral production and trade for different crops.

Ultimately, despite the incentives to increase agricultural production and exports by taking advantage of the increase in international prices in both simulations, losses in capital, land and agricultural productivity are proportionally greater and therefore agricultural production is negatively affected. With the increase in international prices and the rise in the consumer price index, the cost of consuming imported and locally produced agricultural goods increases, severely affecting consumption. This results in a decline in GDP of 1.44% in the first simulation, and 0.90% in the second one.

Table 1 - Macro Results (percentage change from baseline)

Item	**Sim 1**	**Sim 2**
Real GDP at basic prices	-1.44	-0.90

Consumer price index	3.90	3.14
Real consumption budget of households	-3.69	-0.56
Total investment expenditures	-3.84	0.08
Employment	-0.15	-0.02

Source: Calculations based on the CGE model

4.2.Sectoral effects

In the first simulation, the scenario involves damage and losses in the capital and land production factors due to adverse weather events in the Bolivian agricultural sector and the increase in international prices of agricultural products. Therefore, the level of agricultural production is expected to be affected, particularly for the most capital and land intensive crops. The results confirm a decline in production for all agricultural crops. Soybean production, which is the most capital- and land-intensive crop, is the most affected, with production falling by 18.78%, followed by sugar cane production which falls by 13.67%. Subsequently, the production of traditional crops (cereals, fruits, vegetables, and root crops) decreased by 10%-11%, while coca production was the least affected with a decrease of 5.54%.

Concerning the second simulation, since the scenario evaluates a reduction in the total factor productivity (TFP) of the economy, we also expect agricultural production to be affected. The results confirm this hypothesis and show a decrease in agricultural production for all crops. However, contrary to the previous simulation, traditional crops are the most affected this time, with production losses ranging from 5.4% to 7%. Modern crops are affected to a lesser extent with production losses ranging from 1.8% to 3.6%.

Otherwise, as explained in section 4.1 to offset lower levels of agricultural productivity, (Simulation 2), the agricultural sector employs additional workers. Interestingly, employment increases slightly more for the production of traditional crops than for modern ones. Compared to the first simulation, employment decreases across all agricultural crops, with the exception being sugar cane, with traditional crops being the most affected.

In terms of agricultural trade, damages caused to land and agricultural capital (Simulation 1) make Bolivian producers less competitive on the international market, and consequently exports of most crops decline. In contrast, in the second simulation, (in the absence of damage to capital and land), the increase in international prices becomes even more important and provides Bolivian producers with the opportunity to participate on the international market to a greater extent. In this scenario, all agricultural crop exports increase, with the exception of soybean.

As for the non-agricultural sectors, the impact is negative overall. In the first simulation, the negative effects on non-agricultural employment concerns three sectors: the food industry, restaurants and hotels, and livestock. However, sectors such as public administration, machinery and other industries, and commercial and financial services industry, experience a considerable increase in employment, and ultimately in production. It should be noted that skilled labour is mainly concentrated in these sectors, and they are not directly affected by the increase in agricultural prices or damage caused to capital and land. In the second simulation, the increase of employment in the agricultural sector is at the expense of employment in almost all of the other non-agricultural ones. Sectors such as public administration, restaurants and hotels, the textile industry and the food industry are the most affected. Similarly, given that capital remains fixed for the non-agricultural sectors according to the closure rules used in the model, this translates to losses in sectoral production. As a result, non-agricultural exports decline in all sectors in the second simulation, while they increase in the first simulation for almost all non-agricultural sectors. Finally, given the increase in international prices, imports decline in both simulations.

4.3.Gendered effects on employment

As explained in section 4.2, the results suggest that climate change scenarios cause damage to both agricultural and non-agricultural sector employment, resulting in lower labour market participation. Despite a slight increase in agricultural employment in the second simulation, the overall effects on employment are negative. Consequently, the loss of employment in the formal market leads to an increase in domestic workloads in both simulations. Table 2 provides an overview of the impacts of climate change on formal and domestic employment in rural and urban sectors, as well as by gender and skills level.

Table 2 – Gendered impacts of climate change on formal and domestic employment according to skills and location (% change)

		Simulation 1				**Simulation 2**			
Location	**Gender**	Skilled		Unskilled		Skilled		Unskilled	
		Domest	Formal	Domest	Formal	Domest	Formal	Domest	Formal
Rural	Male	-0.92	0.44	0.47	-0.05	0.57	-0.27	-0.33	0.04
	Female	-1.15	0.62	1.35	-0.14	0.61	-0.32	-0.14	0.02
Urban	Male	-0.69	0.13	2.09	-0.37	1.25	-0.22	-0.49	0.10
	Female	-1.36	0.27	2.60	-0.44	1.27	-0.25	-0.51	0.09

Source: Calculations based on the CGE model

Note: Formal=Formal labour market, Domest=Domestic labour market

As mentioned earlier, the results indicate a decrease in employment and therefore a decrease in formal market participation for both simulations, accompanied with an increase in domestic workloads. However, the results vary according to skill level. Thus, the decline in formal market employment in the first simulation concerns only unskilled workers, while in the second simulation it is the employment of skilled workers in the formal market that decreases.

In the first simulation, the results reveal a reduction in the formal employment of the unskilled workforce. This reduction is more significant for women in both rural and urban areas than for men and ultimately leads to increases in their domestic burdens, notably for women. Contrastingly, we see an increase in the formal employment of skilled workers in both rural and urban areas, which results in them being able to reduce their domestic chores. These results might seem somewhat counter-intuitive, but they can be explained by the fact that only 2.9% of the total skilled labour force is employed in the agriculture and livestock sector compared to 17.1% of the total unskilled one. Thus, a decline in agricultural employment affects to a lesser extent the skilled worker. In addition, the skilled worker would be more likely to find employment in the non-agricultural sectors, such as public administration or trade and financial services which benefit from increases in production and employment, as mentioned in section 4.2. The public administration and trade with the financial service sectors together account for 64.9% of the total employment of skilled women compared to 63.8% for skilled men. This explains why skilled women benefit most with increases in employment in the skilled formal market. As a result, skilled workers who are less affected in the labour market see their wages fall by smaller proportions compared to unskilled workers.

As for the results of the second simulation, we have a somewhat different outcome. On the one hand, the increase in formal employment in agricultural crop sector leads to slight increases of unskilled employment, which again is explained by the fact that the agricultural sector in Bolivia is intensive in unskilled labour. This leads to a greater reduction of domestic burdens for men than for women, with rural women reducing their domestic burdens by the least amount (0.14%). On the other hand, the opposite effect is observed among skilled workers. Indeed, the results indicate a reduction in formal skilled employment, which translates into increased domestic burdens for skilled workers. Interestingly, the reduction of formal employment is more significant in rural areas. Once again, women are particularly disadvantaged, mainly in rural areas, where the participation of women in the formal market is reduced to a greater extent than men's (0.32%), making this segment of the population a highly vulnerable group in the context of climate change.

4.4.Impacts on agents

The effects of climate change can be observed through the different economic actors in the Bolivian economy, namely firms, the government and households. In our two simulations, all agents are negatively affected, except firms, however households and particularly their real consumption are the most seriously affected.

Concerning the first simulation, we have an increase in all sources of income for firms (capital income and transfers). It should be noted that firms' income is derived mainly from capital income, and given the decline in capital, mainly in agricultural crops, it generates increases in the capital rental rate. This ultimately leads to a 3% increase in total income and firms' savings.

Concerning the government, we have declines in all sources of income except for transfer revenues. Total public revenues and savings fall by 2.22% and 7.29%, respectively. In the second simulation, the effects of climate change on these agents follow the same trend as the first, but in smaller proportions. Indeed, firms' income and savings increase by 0.37% and 0.39% respectively. While total public revenues and public savings decline by 0.19% and 1.79%.

As for households, results vary considerably as they are disaggregated by gender and location (rural and urban areas). Rural households are the most affected in the first simulation and the least benefitted in the second one. In the first simulation we have a decline in wages and thus a decline in the main source of household income. However, we do see an increase in income from land and capital, which is almost entirely acquired by urban households (see section 3.1). This ultimately compensates for losses in labour income experienced by urban households. Indeed, household income in rural areas declines by 3.0% for men and 2.8% for women, while urban household income increases slightly by 0.7% for both men and women. In the second simulation, incomes increase for all categories of households due to the pressure for higher wages in the agricultural crop sector which seeks to compensate for the losses in productivity, by attracting additional workers. Urban households benefit most here. Indeed, while incomes increase by 2.6% in urban areas for both women and men, in rural areas they increase by only 2.1% and 2.2% for men and women respectively. This result is due to the increase in capital income which is mainly held by urban households.

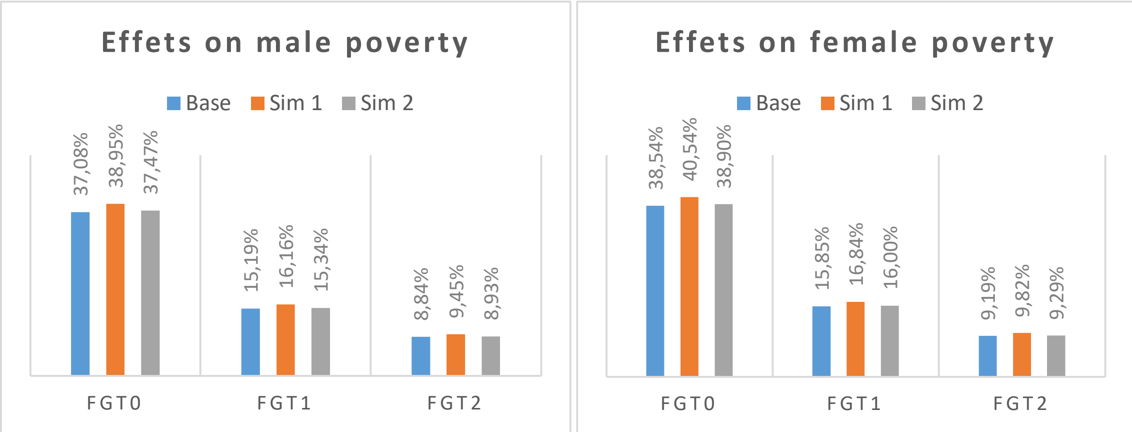
In terms of consumption, we probably have the most surprising effects. As we explained in section 4.1, the combination of rising prices and falling wages in the first simulation severely affects real consumption of all categories of households. Although consumption declines to the same extent for both men and women (3.9% and 3.8% respectively), the disparities between urban and rural areas are particularly large. For example, rural women's income decreases by 6.8 %, compared to 3.2 % for urban women.

With regard to the second simulation, the increase in wages leads to an increase in disposable income for all categories of households. This increase should lead to higher consumption, however due to the fact that increases in income are proportionally lower than the increases of prices, there is a loss of household purchasing power, which in turn leads to a decline in real consumption for all categories of households. Consumption decreases slightly more in male-headed households than female-headed ones (0.6% vs 0.5%). As observed in the previous simulation but to a lesser extent, rural households are the most affected. For example, rural women's income decreases by 0.9% compared to 0.4% for urban women.

4.5.Impacts on Poverty and Inequality

To assess the impact of climatic shocks on the evolution of poverty, we use the (Foster et al., 1984) indexes FGT0, FGT1 and FGT2. FGT0 reflects changes in the incidence of poverty or headcount, FGT1 reflects the depth of poverty, measured by the poverty gap and FGT2 reflects the severity of poverty.

Figure 2 – Effects on poverty (in %)



Source: Calculations based on the Microsimulation model
Note: Sim 1=Simulation 1, Sim 2=Simulation 2, Base = Baseline scenario.

Figure 2 summarises the impacts on poverty. Starting from the baseline scenario, we already see that poverty levels are slightly higher for women than for men. Then, we can then see the evolution of poverty levels for the FGT indicators compared to the levels calculated in the baseline scenario, i.e. in the absence of the climate change scenarios. The results indicate that damage and losses due to climate disasters (Simulation 1) increases the number of poor households, with women more affected than men. Indeed, compared to the baseline scenario, the poverty headcount increases by 2.01% in female-headed households compared to 1.88% in male-headed households. This results in more than 40% of female-headed households being classified as poor. The effects are particularly regressive, with poverty increasing amongst the poorest households (increase in the FGT 2 index for female-headed households).

The decline in agricultural productivity (Simulation 2) also worsens poverty levels, but to a lesser extent than in the first simulation, and also reveals that women are more vulnerable to the effects of climate change than men. In fact, the poverty headcount for women reaches 38.90% compared to 37.47% for men. Similarly, there is an increase in the depth and severity of poverty for both men and women. Again, the vulnerability of the poorest women is becoming worse.

Concerning inequality, we estimate a GINI index of 0.41 for the base scenario, however the inequality gap depending on location is important with rural areas registering higher levels of inequality compared to urban areas (0.48 vs 0.38). With respect to this reference situation, both simulations lead to an increase in inequality, but the first simulation increases inequality to a greater extent. Actually, inequality increases by 0.15% in the first simulation, while in the second simulation it increases by only 0.02%. Similarly, in both simulations, inequality in urban areas increases more than in rural ones, suggesting that climate change exacerbates inequality more in urban Bolivia.

5. Concluding remarks

This study provides an insight into the possible impacts that climate change could have on Bolivian women through two different scenarios. Firstly, we analysed the effects of climate damage on agricultural capital and land (Scenario 1), and secondly, we analysed the effects of a decline in agricultural productivity (Scenario 2). While the results indicate that although the effects of climate change mainly affect the agricultural sectors, the effects also spread to the rest of the sectors, negatively affecting the economy as a whole.

We find that the most negative effects would be felt by households, particularly rural ones, which experience the greatest declines in real consumption. Furthermore, female-headed households are the biggest losers in both simulations, as they are trapped in the poverty circle to a greater extent compared to male-headed ones.

This analysis also seeks to improve the understanding of the interrelationship between climate change, domestic work and formal work by explicitly integrating the domestic tasks performed by Bolivian households according to gender into the simulations. It should be noted that as things stand, women already spend much more time doing unpaid domestic work than men. The results indicate that climate change further increases the domestic work burden on households and significantly the burden on women, which implies that pre-existing gender disparities in Bolivia are further reinforced in the context of climate change.

Our results show that climate change contributes to widening existing gender gaps in the labour market, negatively affecting women's formal employment to greater extent than men's, resulting in heavier domestic burdens for women in both rural and urban areas. However, although the trend is the same in both scenarios with increases in domestic work, the results according to skills level in the first simulation indicate that the increase in domestic burdens is borne by those unskilled, while in the second simulation it is the skilled workers who carry this increase in unpaid work.

The results reveal that Bolivian women are more vulnerable to the effects of climate change than men. Consequently, climate change adaptation policies should focus on gender and consider rural women as a highly vulnerable group. They should also be specific and prioritise the adaptation of crops to climate change such as cereals, tubers and vegetables which are staple foods in Bolivia.

Although the scenarios used in this study considered specific damages to different types of agricultural crops in Bolivia, we think that at a regional level, these same crops could be affected differently because of the wealth of geographical diversity in Bolivia. Therefore, studying specific scenarios at regional levels could be relevant for future research. Similarly, breaking down domestic work into different categories of work could be useful since within domestic work we have different activities such as caring for the elderly or children, cooking activities, fetching water and wood, cleaning activities, amongst others. This would make it possible to identify specific public policies to enable women to lessen their domestic burdens.

6. References

Adzawla, W., Azumah, S.B., Anani, P.Y., Donkoh, S.A., 2019. Gender perspectives of climate change adaptation in two selected districts of Ghana. Heliyon 5, e02854. https://doi.org/10.1016/j.heliyon.2019.e02854
Adzawla, W., Kane, A., 2019. Effects of Climate Shocks and Climate Adaptation through Livelihood Diversification on Gendered Welfare Gaps in Northern Ghana. IJECC 104–119. https://doi.org/10.9734/ijecc/2019/v9i230100
Aliaga, J., Aguilar, T.J., 2009. The Climate Change Effects on the Agricultural Sector of Bolivia. Revista Latinoamericana de Desarrollo Económico 7–30.
Alston, M., 2014. Gender mainstreaming and climate change. Women's Studies International Forum, Special Issue on Gender, Mobility and Social Change - Guest Edited by Lena Nare and Parveen Akhtar 47, 287–294. https://doi.org/10.1016/j.wsif.2013.01.016
Andersen, L.E., Jemio Mollinedo, L.C., Valencia, H., 2014. La economía del cambio climático en Bolivia: Impactos en el sector agropecuario.
Andersen, L.E., Verner, D., Wiebelt, M., 2017. Gender and Climate Change in Latin America: An Analysis of Vulnerability, Adaptation and Resilience Based on Household Surveys. Journal of International Development 29, 857–876. https://doi.org/10.1002/jid.3259
Ashwill, M., Blomqvist, M., Salinas, S., Ugaz-Simonsen, K., 2011. Gender Dynamics and Climate Change in Rural Bolivia. World Bank. https://doi.org/10.1596/27161
Buechler, S., 2009. Gender, water, and climate change in Sonora, Mexico: implications for policies and programmes on agricultural income-generation. Gender & Development 17, 51–66. https://doi.org/10.1080/13552070802696912
Byerlee, D., Diao, X., Jackson, C., 2005. Agriculture, Rural Development, and Pro-poor Growth. Agriculture and RuralDevelopment Discussion Paper 21. 72.
Canelas, C., Salazar, S., 2014. Gender and Ethnicity in Bolivia, Ecuador, and Guatemala (No. 11), Working Papers, Working Papers. Development and Policies Research Center (DEPOCEN), Vietnam.
Castells-Quintana, D., Lopez-Uribe, M. del P., McDermott, T.K.J., 2018. Adaptation to climate change: A review through a development economics lens. World Development 104, 183–196. https://doi.org/10.1016/j.worlddev.2017.11.016
CEPAL, 2019. Panorama Social de América Latina 2019. CEPAL.
CEPAL, 2001. Uso del tiempo y trabajo no remunerado: dimensiones invisibles del bienestar [WWW Document]. URL http://onat.tucuman.gov.ar/Assets/docs/20170905_seminario/11_Nieves_Rico.pdf (accessed 5.14.20).
Chitiga, M., Maisonnave, H., Mabugu, R., Henseler, M., 2019. Impact of climate change on vulnerable groups on South African labour markets [WWW Document]. Presented at the 22nd Annual Conference on Global Economic Analysis, Warsaw, Poland. URL http://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=5822
Cockburn, J., Fofana, I., Decaluwe, B., Mabugu, R., Chitiga, M., 2007. A Gender-Focused Macro-Micro Analysis of the Poverty Impacts of Trade Liberalization in South Africa, in: J. Lambert, P. (Ed.), Equity, Research on Economic Inequality. Emerald Group Publishing Limited, pp. 269–305. https://doi.org/10.1016/S1049-2585(07)15011-0
Decaluwé, B., Lemelin, A., Robichaud, V., Maisonnave, H., 2013. PEP-1-1 (Single-Country, Static Version) [WWW Document]. PEP. URL https://www.pep-net.org/pep-1-1-single-country-static-version (accessed 4.11.20).
Demetriades, J., Esplen, E., 2010. The gender dimensions of poverty and climate change adaptation. Social dimensions of climate change: Equity and vulnerability in a warming world 133–143.
Denton, F., 2002. Climate change vulnerability, impacts, and adaptation: Why does gender matter? Gender & Development 10, 10–20. https://doi.org/10.1080/13552070215903
Design, S., Lorini Lázaro, L., Fundación el JUNUSÚ del Desarrollo, Viceministerio de Defensa Civil-VIDECI, 2017. Migración Cambio Climático Desde la perspectiva de la gestión de

riesgos de desastres en los municipios de Bolpebra, San ignacio de Moxos y Santa Ana del Yacuma.
Dey, A., Singh, G., Gupta, A.K., 2018. Women and Climate Stress: Role Reversal from Beneficiaries to Expert Participants. World Development 103, 336–359. https://doi.org/10.1016/j.worlddev.2017.07.026
Eastin, J., 2018. Climate change and gender equality in developing states. World Development 107, 289–305. https://doi.org/10.1016/j.worlddev.2018.02.021
Field, C.B., Barros, V.R., Mastrandrea, M.D., Mach, K.J., Abdrabo, M.A.-K., Adger, N., Anokhin, Y.A., Anisimov, O.A., Arent, D.J., Barnett, J., Burkett, V.R., Cai, R., Chatterjee, M., Cohen, S.J., Cramer, W., Dasgupta, P., Davidson, D.J., Denton, F., Döll, P., Dow, K., Hijioka, Y., Hoegh-Guldberg, O., Jones, R.G., Joner, R.N., Kitching, R.L., Kovats, R.S., Larsen, J.N., Lin, E., Lobell, D.B., Losada, I.J., Magrin, G.O., Marengo, J.A., Markandya, A., McCarl, B.A., McLean, R.F., Mearns, L.O., Midgley, G.F., Mimura, N., Morton, J.F., Niang, I., Noble, I.R., Nurse, L.A., O'Brien, K., Oki, T., Olsson, L., Oppenheimer, M., Overpeck, J.T., Pereira, J.J., Poloczanska, E.S., Porter, J.R., Pörtner, H.-O., Prather, M.J., Pulwarty, R.S., Reisinger, A., Revi, A., Romero-Lankao, P., Ruppel, O.C., Satterthwaite, D.E., Schmidt, D.N., Settele, J., Smith, K.R., Stone, D.A., Suarez, A.G., Tschakert, P., Valentini, R., Villamizar, A., Warren, R., Wilbanks, T.J., Wong, P.P., Woodward, A., Yohe, G.W., 2014. Summary for Policymakers [WWW Document]. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. URL https://epic.awi.de/id/eprint/37531/ (accessed 4.11.20).
Fischer, G., Shah, M., N. Tubiello, F., van Velhuizen, H., 2005. Socio-economic and climate change impacts on agriculture: an integrated assessment, 1990–2080. Philos Trans R Soc Lond B Biol Sci 360, 2067–2083. https://doi.org/10.1098/rstb.2005.1744
Fofana, I., Cockburn, J., Décaluwé, B., 2003. Modeling male and female work in a computable general equilibrium model applied to Nepal. Université Laval. 54.
Fontana, M., 2004. Modelling the effects of trade on women, at work and at home: comparative perspectives. Economie internationale no 99, 49–80.
Fontana, M., Wood, A., 2000. Modeling the Effects of Trade on Women, at Work and at Home. World Development 28, 1173–1190. https://doi.org/10.1016/S0305-750X(00)00033-4
Foster, J., Greer, J., Thorbecke, E., 1984. A Class of Decomposable Poverty Measures. Econometrica 52, 761–766. https://doi.org/10.2307/1913475
Galindo, L.M., Samaniego, J., Alatorre, J.E., Ferrer, J., Reyes, O., 2014. Cambio climático, agricultura y pobreza en América Latina 108.
Goh, A.H.X., 2012. A literature review of the gender-differentiated impacts of climate change on women's and men's assets and well-being in developing countries: (No. 106), CAPRi working papers, CAPRi working papers. International Food Policy Research Institute (IFPRI).
Hertel, T., Rosch, S.D., 2010. Climate change, agriculture and poverty, Policy Research Working Papers. The World Bank. https://doi.org/10.1596/1813-9450-5468
IFPRI, Bank (IDB), I.-A.D., Studies (INESAD), I. for A.D., Economy (IfW), K.I. for the W., 2018. Bolivia Social Accounting Matrix, 2012. https://doi.org/10.7910/DVN/29015
ILOSTAT, 2019. Database Archives. ILOSTAT. URL https://ilostat.ilo.org/downloads/database/ (accessed 4.15.20).
INE, 2019. Encuesta de Hogares 2019 [WWW Document]. Instituto Nacional de Estadística. URL https://www.ine.gob.bo/index.php/banco/base-de-datos-sociales (accessed 4.15.20).
INE, 2018a. Encuesta Continua de Empleo 4T 2018 [WWW Document]. Instituto Nacional de Estadistica. URL https://www.ine.gob.bo/index.php/banco/base-de-datos-sociales (accessed 4.15.20).

INE, 2018b. Encuesta de Hogares 2018 [WWW Document]. Instituto Nacional de Estadistica. URL https://www.ine.gob.bo/index.php/censos-y-banco-de-datos/censos/bases-de-datos-encuestas-sociales/ (accessed 8.25.20).
IPCC, 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, EPIC3Geneva, Switzerland, IPCC, 151 p., pp. 151, ISBN: 978-92-9169-143-2. IPCC, Geneva, Switzerland.
Jemio, L.C., Andersen, L.E., Ludeña, C., de Miguel, C., Pereira, M., 2014. La economía del cambio climático en Bolivia: Estimación de impactos en equilibrio general | Publications [WWW Document]. URL https://publications.iadb.org/publications/spanish/document/La-econom%C3%ADa-del-cambio-clim%C3%A1tico-en-Bolivia-Estimaci%C3%B3n-de-impactos-en-equilibrio-general.pdf (accessed 4.11.20).
Klasen, S., 2020. From 'MeToo' to Boko Haram: A survey of levels and trends of gender inequality in the world. World Development 128, 104862. https://doi.org/10.1016/j.worlddev.2019.104862
Kreft, S., Eckstein, D., Dorsch, L., Fischer, L., Germanwatch, 2016. Global Climate Risk Index 2016 Who Suffers Most From Extreme Weather Events? Weather-related Loss Events in 2014 and 1995 to 2014.
Lambrou, Y., Piana, G., 2006. Gender: the missing component of the response to climate change. Sustainable Development Department, Food and Agriculture Organization of the United Nations (FAO) 45.
Lundvall, J.M., Garriga, S., Bonfert, A.T., Tas, E.O., Villegas-Otero, M., 2015. Bolivia - Challenges and constraints to gender equality and women's empowerment (No. 103087). The World Bank.
McKune, S.L., Borresen, E.C., Young, A.G., Auria Ryley, T.D., Russo, S.L., Diao Camara, A., Coleman, M., Ryan, E.P., 2015. Climate change through a gendered lens: Examining livestock holder food security. Global Food Security 6, 1–8. https://doi.org/10.1016/j.gfs.2015.05.001
Morales, R., Agramont, D., Gomez-Soto, E., Parisaca Quipse, E., Gomez, F., Illanes-Yujra, J., Cueto, M., Soruco, X., 2017. Trade Bust, Labor and Wage Policy in Bolivia: A CGE Approach (SSRN Scholarly Paper No. ID 3163581). Social Science Research Network, Rochester, NY.
Nelson, G.C., Mark, R., Koo, J., Richard, R., Sulser, T., Zhu, T., Ringler, C., Msangi, S., Palazzo, A., Batka, M., Magalhaes, M., Valmonte-Santos, R., Ewing, M., Lee, D., 2009. Climate Change: Impact on Agriculture and Costs of Adaptation. Intl Food Policy Res Inst.
Paudyal, B.R., Chanana, N., Khatri-Chhetri, A., Sherpa, L., Kadariya, I., Aggarwal, P., 2019. Gender Integration in Climate Change and Agricultural Policies: The Case of Nepal. Front. Sustain. Food Syst. 3. https://doi.org/10.3389/fsufs.2019.00066
Ponce, R., Blanco, M., Giupponi, C., 2014. The economic impacts of climate change on the Chilean agricultural sector: A non-linear agricultural supply model. Chilean journal of agricultural research 74, 404–412. https://doi.org/10.4067/S0718-58392014000400005
Quisumbing, A.R., Kumar, N., Behrman, J.A., 2018. Do shocks affect men's and women's assets differently? Evidence from Bangladesh and Uganda. Development Policy Review 36, 3–34. https://doi.org/10.1111/dpr.12235
Rubiano-Matulevich, E., Viollaz, M., 2019. Gender Differences in Time Use: Allocating Time between the Market and the Household, Policy Research Working Papers. The World Bank. https://doi.org/10.1596/1813-9450-8981
Sevillano Cordero, R.C.S., 2012. Estimacio´n de las Elasticidades de Armington y CET: Una aproximacio´n de Ma´xima Entrop´ıa Generalizada 17.

Siddiqui, R., 2005. Modelling Gender Dimensions of the Impact of Economic Reforms on Time Allocation among Market, Household, and Leisure Activities in Pakistan. The Pakistan Development Review 44, 615–639.
Thurlow, J., Zhu, T., Diao, X., 2009. The Impact of Climate Variability and Change on Economic Growth and Poverty in Zambia [WWW Document]. URL http://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=3144
UDAPE, 2015. Evaluación de daños y pérdidas por eventos climáticos Bolivia 2013-2014.
Vargas, R., Cabrera, M., Cicowiez, M., Escobar, P., Hernández, V., Cabrera, J., Guzmán, V., 2018. Climate risk and food availability in Guatemala. Environment and Development Economics 23, 558–579. https://doi.org/10.1017/S1355770X18000335
Viscarra, F., 2014. Climate change impacts and efficient adaptation options in the Bolivian agriculture : from crop models to integrated assessments.
Viscarra, F.E., Giupponi, C., Mendelsohn, R., 2018. Impactos, medidas de adaptación y costos sociales del cambio climático en el sector agrícola del Estado Plurinacional de Bolivia.
WDI, 2019. World Bank Open Data | Data [WWW Document]. URL https://data.worldbank.org/ (accessed 4.15.20).
WDI, 2018. World Bank Open Data | Data [WWW Document]. URL https://data.worldbank.org/ (accessed 4.15.20).