The gender impact of public climate change adaptation policies on food security in Cameroon.

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Date July 2023

Working Paper 2023-07

PEP Working Paper Series
ISSN 2709-7331

Résumé

L’agriculture fait partie des secteurs les plus touchés par le changement climatique dans les pays d’Afrique Subsaharienne. Au regard de son importance dans l’économie camerounaise, elle se positionne comme le principal déterminant de la sécurité alimentaire, menacé par le changement climatique. Les femmes jouent un rôle majeur dans ce secteur. Elles représentent plus de la moitié de la main-d’œuvre et contribuent à plus de 80% de la production alimentaire. Toutefois, elles exercent davantage dans le secteur informel, ce qui les rend plus vulnérables. Cette étude évalue l’impact différentié selon le genre d’une politique de subvention des prix des engrais sur la sécurité alimentaire, en s’appuyant sur un Modèle d’équilibre général calculable et une modélisation économétrique. Les résultats montrent qu’une telle politique atténue les effets du changement climatique sur la sécurité alimentaire, tout en diminuant la vulnérabilité des femmes face à ce phénomène, notamment chez celles vivant en milieu rural.

JEL : Q54 ; Q18 ; J16 ; C68 ; O55

Mots clés : Changement climatique, sécurité alimentaire, genre, modèle EGC, Cameroun.

Abstract

Agriculture is one of the sectors most affected by climate change in Sub-Saharan African countries. Considering its importance to the Cameroonian economy, it is positioned as the main determinant of food security, under threat by climate change. Women play a major role in this sector. They represent more than half of the workforce and contribute to more than 80% of food production. However, they work predominantly in the informal sector, which makes them more vulnerable. This study assesses the gender-differentiated impact of a fertilizer price subsidy policy on food security, using a Computable General Equilibrium Model and econometric modeling. The results show that a policy of this kind, can mitigate the effects of climate change on food security, while at the same time reducing women's vulnerability to the phenomenon, especially among those living in rural areas.

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

Keywords: Climate change, food security, gender, CGE model, Cameroon.

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Acknowledgements

This work was carried out with the financial and scientific support of the Partnership for Economic Policy (PEP) through funding provided by Global Affairs Canada (GAC).

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1. Introduction

The effects of climate variability and change can be felt in virtually every country in the world, and represent a serious challenge for the entire planet. This is reflected in the summary reports produced by the Intergovernmental Panel on Climate Change (IPCC, 2007, 2014, 2021). The most recent one states that the world's climate is changing, and faster than expected (IPCC, 2021).

These events are characterised by long-term changes in temperature and precipitation. This trend can be observed in terms of rainfall intensity and in the increase in the occurrence of extreme events and natural disasters. According to the IPCC report (2021), climatic changes will increase in all regions in the coming decades. There will be more frequent heat waves, hot seasons and shorter cold seasons. With a 2°C rise in temperatures, extreme heat will tend to reach critical tolerance thresholds for agriculture and public health.

The impact of climate change varies from one area to another. Some studies show that the countries most vulnerable to climate change are those with limited resources available to deal with it (Campbell-lendrum and Corvala, 2007; IPCC, 2014), and whose populations are the most deprived. These include developing countries, particularly those in sub-Saharan Africa, which are highly dependent on agriculture, which plays a central role in their economies.

This sector, which employs more than 55% of the working population (Ayodele, 2019), is the motor of industrial growth and of the structural transformation of their economies. Women play a key role according to Suwadu and Hathie (2020) as they account for about 50% of the agricultural labour force as well as contributing to the production of between 60 to 80% of food in the region (Njobe and Kaaria, 2015). Despite this important role in agriculture, women are restricted to subsistence farming and are not sufficiently represented in higher value-added activities.

Moreover, women work more frequently in the informal sector, and are disadvantaged compared to men in terms of decision-making power and control over productive resources - especially land - which severely limits their access to funding. Furthermore, due to their greater involvement in household activities, women have less time to devote to agricultural activities. This adversely affects their agricultural productivity and, consequently, the amount of revenue they can generate (Njobe and Kaaria, 2015).

Thus, despite the important role they play in the agricultural sector, women are also the most vulnerable (Adzawla et al., 2019; Paudyal et al., 2019; Rao et al., 2019; Eastin, 2018). This vulnerability is further exacerbated by climate change, which adds to the burden of domestic work that women typically bear. (Eastin, 2018).

Given the degradation of land and the disruption of seasons leading to higher temperatures and lower rainfall, the agricultural sector is among those most affected by climate variability. According to the IPCC (2014), about 46% of Africa's land area is subject to soil degradation, affecting an estimated 485 million people and causing losses of about US$9.3 billion per year. Worse still, about 70-80% of the continent's cultivated land is degraded, resulting in losses of 30-60 kg of nutrients per hectare per year (IPCC, 2014).

In addition, the combined effects of insufficient rainfall, very high temperatures, and increased flooding and droughts makes it almost impossible for some crops to grow or negatively affects their yields (Abaje et al., 2013; Zhang et al., 2015; Winkler et al., 2017). According to Wheeler and Von Braun (2013), this decrease in productivity will have a strong negative impact on food security. According to the Committee on World Food Security (CFS, 2013) food security is built on four pillars: availability, access, utilisation and stability (or vulnerability). It is across these key pillars that the effects of climate change on food security are most noticeable. In view of its economic importance, agriculture is the main sector through which climate change affects food security (Kotir, 2011).

Cameroon is not sheltered from climate change and its adverse effects, which vary from one Agroecological Zone (AEZ) to another[1]. There has been a steady decline in rainfall, a gradual increase in temperatures and an upsurge in extreme events (strong winds and violent storms, floods, landslides, mudslides, rockfalls, landslides, etc.) across most of the country (Amougou et al., 2014, 2015, 2016; Abossolo et al., 2015). This affects agricultural production, food security and the incomes of farming households (MINEPDED, 2015). Thus, about 20.4% of households in the country are food insecure (particularly in the Far North, 33.7%). Among these households, nearly 26% are headed by women (MINADER, WFP and FAO, 2020).

Taking this into account, and in order to meet the requirements of the United Nations Framework Convention on Climate Change (UNFCCC), the Cameroonian government developed a National Climate Change Adaptation Plan (PNACC) in 2015. Addressing climate change is now a key priority in various sectoral policies and in the new National Development Strategy 2020-2030 (SND30). A number of adaptation measures have been implemented over the past few years: distribution of improved seeds, adjustment of the growing season and distribution of fertilisers with a preference for ecological ones. Moreover, government subsidies for inputs (fertilisers, improved seeds, small agricultural tools and equipment) and assistance to farmers (capacity-building) have helped mitigate the risk of below-average production (Cameroon Food Security Outlook, 2020).

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[1] Due to its climatic diversity, Cameroon counts five (05) AEZs: the Sudano-Sahelian Zone (SSZ), the High Savannah Zone (HSZ), the Moist Savannah Zone (MSZ), the Bimodal Forest Zone (BFZ), and the Mangrove Zone (MZ)

However, the gender dimension is not specifically taken into account when implementing these measures, and more specifically, regarding the formulation of the SND30 objective on combating climate change. Even though 90% of food production is produced on family farms, with women contributing to an estimated 80% of this production (WFP, 2017). Over half of the workers in the agricultural sector are women who are more engaged in subsistence farming (71.6% of workers in the informal agricultural sector are women). In order to facilitate the inclusion of the gender dimension into the objectives of the SND30 related to climate change, it is important to analyse the gender-differentiated impact of climate change and public adaptation policies, particularly on food security, which is another major challenge for the Cameroonian government.

The objective of this study is to assess the gender-differentiated impacts of public climate change adaptation policies on food security.

Specifically, it is a question of measuring:

- the differentiated impact of climate change on food security in Cameroon according to gender and AEZ, notably on availability, accessibility and vulnerability;
- the gender-differentiated impact of public climate change adaptation policies on food security in Cameroon.

To conduct this study, we use a static Computable General Equilibrium Model (CGE), combined with econometric modelling. CGEMs are economic analysis tools that capture the interactions between productive branches of activity, the labour market and economic agents. Given the high climatic variability across the different agro-ecological zones (AEZs) in Cameroon, this model disaggregates the agricultural branches by AEZ and by the main food products grown in the country, so that it is possible to identify the effects of climate change on agricultural production in each zone.

The climate change scenario implemented in the CGEM was estimated econometrically using ARDL regressions, based on the studies of Belloumi (2014) conducted on Eastern and Southern African countries, and of Yobom (2020) carried out on 12 countries in the Sahel zone. The estimates are based on data from FAOSTAT, the World Development Indicators (WDI) and the Climate Change Knowledge Portal, while the CGEM is calibrated using a SAM for the year 2018. This SAM is disaggregated to take into account the high segmentation of the Cameroonian labour market, gender and the distinction between female and male-headed households.

2. Review of the literature

2.1 Climate change, food security and gender

According to the IPCC (2007), climate change negatively impacts human life determinants, including food security. The main transmission channel for these effects on food security pillars is the decline in agricultural production, linked to declining crop yields (FAO, 2008; Hall et al., 2017; Cabral, 2011; Carleton and Hsiang, 2016; Schlenker and Roberts, 2009; Burke and Emerick, 2016).

Climate change not only affects growth and income distribution, but also the demand for agricultural products (Smith et al., 2000). Droughts, rising temperatures, floods, reduced rainfall, and the irregular duration of seasons cause land degradation, and affect the growth of many crops (IPCC, 2014). Yet agriculture is a key sector of the economy, providing an essential source of job creation and poverty reduction in developing countries (FAO, 2011).

Moreover, agriculture is the sector where women are predominantly employed in these countries. They represent about 43% of the agricultural workforce in developing countries (FAO, 2011), and nearly 50% of the workforce in African countries (Njobe and Kaaria, 2015). Despite this strong representation and important contribution to the agricultural sector, women face many difficulties. They have considerably less access in comparison to men to land, to agricultural inputs (fertilizers), to credit and other forms of funding, to modern production techniques, to education, etc. (FAO, 2011).

As well as these agricultural activities, women are also more engaged than men in carrying out domestic activities such as cooking, childcare, fetching firewood, washing clothes and dishes, etc. They are therefore more vulnerable to climate change shocks in the agricultural sector, which in turn tends to further deepen gender inequalities. Women and girls are likely to experience increased inequalities as a result of the effects of climate change not only because they are often poorer, but also because of their socially constructed roles, rights and responsibilities. A UN study (2019) refers to these as 'systemic inequalities'.

Another transmission channel for the impacts of climate change on food security is through livestock production. Other indirect channels of climate change impacts on food security include health, global price volatility, trade flows, etc. (Nelson et al., 2010; Breisinger et al., 2009). In addition, climate change-induced soil degradation very often leads to the need to use large amounts of fertiliser. Given the difficulties in obtaining these products, due mainly to insufficient financial means, farmers, notably those with the smallest holdings, use very little fertiliser. Despite being one of the key inputs into the agricultural sector, the level of fertiliser use is below the target level of at least 50 kg of nutrients per hectare of arable land, set in the 2006 Abuja Declaration, according to the UN's State of Food Security and Nutrition in the 2019 World report.

Given the financial difficulties described above, it is much more difficult for women to include fertiliser in their production processes.

2.2 Climate change and gender analysis models

From a methodological point of view, most studies that examine the gender-differentiated effects of climate change mainly use two types of analysis: partial equilibrium analyses (econometric methods, agronomic methods, etc.) and general equilibrium analyses (in particular CGEM).

2.2.1 Partial equilibrium analyses

Several authors adopt the partial equilibrium analysis to demonstrate the impact of climate change or associated mitigation policies. In this way, they achieve gender-differentiated results. Generally, it is accepted that climate factors affect men and women differently, thus exacerbating pre-existing gender disparities (Manata and Papazu, 2009). Terry (2009) highlights the complexity and dynamics of the links that exist between climate change and gender. This is seen in terms of vulnerability, mitigation as well as adaptation to the effects of climate change.

The transmission channels through which climate change impacts women and men differently are multiple. According to Anderson (2009) and Parikh (2010), women and children are 14 times more likely to die or to be injured than men as a result of a natural disaster, and experience greater secondary impacts through lost or reduced economic opportunities and increased workloads.

In line with this, Alston (2015) examines the impact of national climate change adaptation policies in Bangladesh on livelihood strategies and health, with a particular focus on the impact on gender relations. The author finds that although women have an important role to play in helping communities cope with the effects of climate change, cultural customs and practices often work against them. This explains why some agreements, such as the Cancun Agreement from the 16th COP on climate change in December 2010 in Mexico, recognise that women are among the stakeholders who must be mobilised to act effectively on all aspects of climate change. It is therefore important that developing countries develop and implement strategies that take into account the important role that women can play as well as their vulnerability.

Paudyal et al (2019) find that climate change in Nepal impacts women more than men, and more so in countries where women's participation in agriculture is very high and where there is an existing gender gap regarding access to knowledge, technology, markets and workload. Eastin (2018) shows that climate factors increase the burden of domestic work, especially for women, which reduces the amount of time they spend in paid work, thus increasing their vulnerability.

In addition, empirical findings on the gender-related effects of climate change on food security in a partial equilibrium analysis vary significantly across areas (urban, rural) and contexts. Indeed, the results observed in the literature differ from one country to another provided that gender roles and relations are closely linked to a specific context (Verner, 2012). Yobom (2020) analyses the link between climate change and food security in the Sahel countries. The author takes into account socio-economic factors and climatic conditions that play a significant role in food security. The impact was assessed by the use of a panel data model with lagged variables of interest and the results show that drought and floods negatively affect food security.

The findings suggest that the low level of economic development, population growth and food price inflation make it impossible to achieve food security. The study also revealed that between drought and floods, floods have the most negative impact on food security. However, it does not take into account the gender aspect. Alston (2013) finds that in some areas, notably Australia, the Pacific and Bangladesh, sexes differ in terms of their vulnerability to climate change. In such contexts, drought and water insecurity have left women highly vulnerable, due to their lack of land ownership and inequality in the decision-making process.

In addition, this study provides information on the fact that despite increased domestic violence experienced by women in these regions due mainly to the stresses of agricultural activity, existing adaptation policies focus on industrial and economic factors rather than on these social factors, leaving women very vulnerable and in even more difficult circumstances. Based on data collected in Ghana, Glazebrook and Noll (2020) discuss the effects of extreme weather events on female subsistence farmers and argue that women have important knowledge to share in terms of adaptation measures. Once again in the case of Ghana, Adzawla et al (2019) show that the impact of climate change on income is much more pronounced for women than for men, and that men possess a greater capacity to adapt than women.

Nevertheless, Andersen et al (2016), carrying out studies in Peru, Brazil and Mexico, come to opposite conclusions. Based on a combination of the level of household income per capita and the degree of diversification of this income, they show that female-headed households have stronger resilience capacities and a greater ability to withstand the impacts of climate change than male-headed households. This, despite the fact that women generally have lower levels of education than men.

In Cameroon, there are some studies that have used a partial equilibrium analysis framework to study the impact of climate change. Molua and Lambi (2010), studying the impact of climate change on agriculture from a survey of 800 Cameroonian farmers, conclude that climate remains the main factor determining the type of agriculture practiced in the country. Chabejong (2016) as well as Pemuda (2014) show that the population in the far north experiences an increasing level of malnutrition. This is partly due to extreme droughts brought about by climate change and its negative impact on agricultural production.

These partial equilibrium studies have some limitations. While they use cross-sectional survey data (micro data), their results are still based on individual perceptions and adaptation measures to climate change, and do not take into account the long-term uncertainties and analytical frameworks associated with climate change (Sawadogo and Fofona, 2021). Additionally, this analytical framework does not allow for the integration of the effects of climate change on the economy as a whole. Very frequently, it is applied to a single sector, usually agriculture.

A further limitation of partial equilibrium analyses is essentially methodological. Indeed, the manner in which climate change is understood, the measurement of food security and the econometric approach used to study the impact of climate change on food security could lead to mixed results and explain the existence of controversies in the literature (Webb et al., 2006; Coates et al., 2006). In terms of the magnitude of climate change, it is often described in the literature in terms of increasing variability in specific weather conditions. These include temperature, soil, precipitation, wind, intensity or duration of floods or droughts and tropical storms (IPCC, 2014; Molua, 2002, 2007; Pemunta, 2014; Kurukulasuriya and Rosenthal, 2003; Seo and Mendelsohn, 2008; Amthor, 2001).

As with climate change, there is no standardised measure of food security that is suited to all contexts and cultures. Barrett (2010) attributes this difficulty in measurement to the fact that food insecurity is a multidimensional concept that covers aspects of availability, access and utilisation.

2.2.2 General equilibrium analyses

Studies that employ a general equilibrium analysis, capture the impact of climate change in different ways (Arndt and Thurlow, 2015; Zidouemba, 2017; Sawodogo et al., 2020; Bezabih et al., 2011; Reid et al., 2008; Thurlow et al., 2008; Gerard et al., 2002). Some take into account climate variation factors such as rainfall, drought or temperature, using stochastic or probabilistic scenarios (Arndt and Thurlow, 2015). Others, however, are more interested in the future development of extreme weather events and disaster risks (Zhong et al., 2019). Another category of studies takes into account climate change through the decline in land productivity and agricultural yields, using deterministic scenarios (Ahmed et al., 2011).

In Burkina Faso, Sawadogo and Fofona (2021) show that climate change affects women in agriculture to a greater extent than men, both in terms of income and poverty. One explanation for this is that men's greater diversity of economic activities allows them to better adapt to climate change. Again focusing on Burkina Faso, Zidouemba (2014) tests a scenario assuming a deterioration in agricultural productivity resulting from a decline in natural resources and climate change. The results show that a deterioration in agricultural productivity significantly increases food insecurity among the poor and greatly reduces overall economic growth. Similarly, other studies describe land degradation scenarios as causing lower productivity in the agricultural sector [Diao and Sarpong (2011) for Ghana; Wiig et al. (2001) for Tanzania and Grepperud et al. However, Gérard et al (2012), adopt a somewhat different approach for the case of Mali. They use a micro-simulated CGE model to take into account the pillars "availability and access to food security", "climatic hazards", "unemployment", "difficulty for the workforce to change jobs", to test different scenarios on trade liberalisation.

In general, these studies have two methods of taking the gender dimension into account in the CGEM. These are the gender disaggregated approach and the two sector approach.

The first approach is to disaggregate the standard variables (production, production factors, households, etc.) by gender (Maisonnave and Escalante, 2020; Arndt et al, 2011; Waongo et al., 2015). This option is limited by the fact that the behavioural rules of the various economic agents in the model remain largely governed by neoclassical principles and do not clearly refer to unpaid work.

The two-sector approach, on the other hand, involves introducing the market sector and non-market reproductive activities (domestic work and leisure) into the model (Zidouemba et al., 2018). The drawback of this method is that it does not clearly highlight the interactions that exist between non-market activities (domestic work and leisure) and market activities. To provide a complete picture, some studies try to combine the two aspects of gender mainstreaming in the CGEM (Sawadogo and Fofona, 2021).

The main limitation of the above-mentioned studies is that they very often do not take into account the gender dimension of the analysis sample. To our knowledge, only the study by Nchu et al (2019) focusing on women, shows that there is an inverse relationship between discriminatory cultural practices and female farmers' ability to adapt to climate change, making women more vulnerable to climate conditions in the short and long term. No studies exist in Cameroon that use CGEMs to analyse the gender-differentiated impact of climate change or climate change adaptation measures.

This present study contributes to the existing literature on the effects of climate change and adaptation measures in developing countries as a whole and in Cameroon in particular. In addition to not taking into account the gender aspect of distributional impacts, the economy as a whole and the methodological limitations, these earlier studies also do not take into account the climatic diversity of Cameroon. To address this shortcoming, we integrate into a CGE analysis, the gender-specific characteristics of the labour factor and distinguish between male- and female-headed households in order to better assess the differentiated impact of climate change. We also include a regional aspect in our model, by disaggregating the agricultural branches by agro-ecological zones. This makes it possible to take climate variability into account and to carry out a more detailed analysis of the simulation results.

3. Data

This study is based on a SAM constructed using data from Cameroon's national accounts for the year 2018, which is a year without any major shocks or particular disasters. The choice of the year 2018 is justified by the fact that it is the most recent year for which the National Institute of Statistics of Cameroon has a Supply and Use Table (SUT) and an Integrated Economic Accounts Table (IEAT). In order to take into account the regional aspect on the one hand, and the gender aspect on the other, this SAM is disaggregated using data from the second Employment and Informal Sector Survey (EESI2), the fourth Cameroonian Household Survey (ECAM4), additional data from the Ministry of Agriculture and data from the 2nd General Census of Enterprises (RGE2). Data from the fourth Cameroonian Household Survey (ECAM4) also enabled the disaggregation of the household account.

There are 58 branches of activity in the SAM, 42 of which relate to agricultural production (13 agricultural products cross-referenced with the 4 AEZs[2] depending on whether they are produced in a given AEZ) and 16 branches which relate to non-agricultural activities. Indeed, the disaggregation of branches of activity takes the climatic diversity of Cameroon into account. It also includes 59 products. We distinguish four categories of labour in the agricultural branches by taking into account the informal dimension and gender, while in the non-agricultural branches we distinguish eight categories of labour according to the informal dimension, skills and gender. Households were disaggregated into four categories according to the gender of the household head and the area of residence. The SAM also includes an account for firms, four accounts for the government (the different groups of duties and taxes have been highlighted) and an account for the rest of the world.

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[2] The High Savannah Zone and the Bimodal Forest Zone (HSZ and BFZ) were combined due to lack of data

4. Methodology

4.1 THE CGEM

For this study, we adopt a dual methodological approach. First, we perform econometric modelling by using an AutoRegressive Distributed Lag (ARDL) approach to estimate changes in agricultural yields as a result of climate change. This modelling draws on the work of Belloumi (2014) on Eastern and Southern African countries and Yobom (2020) on 12 countries in the Sahel region. Subsequently, these variations in agricultural yields caused by climate change are integrated into a CGE model tailored from the static version of the Pep 1-1 CGE model developed by Decaluwé et al.

Like Wamadini et al (2019), we assume that there are several producers who are trying to maximise their profit under the technological constraint and market-determined prices. The model includes several production branches including those of the agricultural sector (disaggregated by AEZ), The focus on the branches of production is based on the goods that are included in the calculation of the consumer price index for Cameroon and which are likely to be affected by climate change.

Although largely inspired by the Pep 1-1 model, our model differs from it in several respects, notably in the modelling of the labour market and the regionalisation of agricultural production. In order to take into account the highly segmented nature of the labour market in Cameroon, we model the agricultural labour market differently from the non-agricultural labour market. Indeed, while the agricultural labour market is segmented according to informality and gender, the non-agricultural labour market is segmented according to skills, informality and gender. Furthermore, in order to take into account the regional variations of climate in Cameroon, the agricultural sector was not only disaggregated according to the main crops, but also according to the different AEZs. Using this disaggregation, we assume a specific labour market for each AEZ in the agricultural sector.

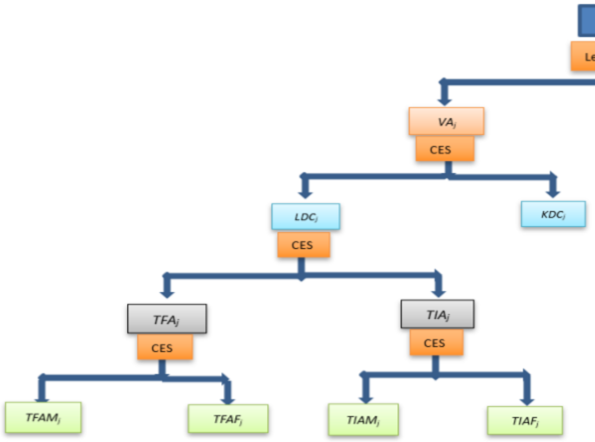
Therefore, for each branch of production in the agricultural sector, a representative firm uses a combination of different inputs to produce a good. The optimal combination is determined by profit maximisation, constrained by the production technology. In order to capture the different degrees of input substitution, the production process is represented using nested functions.

At the first level, value added is combined with intermediate consumption according to a Leontief-type function. In other words, there is no substitution possible between these two aggregates which are always combined in the same proportions. The same applies to the various intermediate consumptions for each product.

Concerning value added, there is an imperfect substitution between capital and labour, represented by a CES (Constant Elasticity of Substitution) type function. The same assumption is made regarding the possibility of substituting different categories of workers at different levels.

We introduce, for example, a low elasticity of substitution between formal agricultural workers and informal agricultural workers, between female formal agricultural workers and male formal agricultural workers and between female informal agricultural workers and male informal agricultural workers.

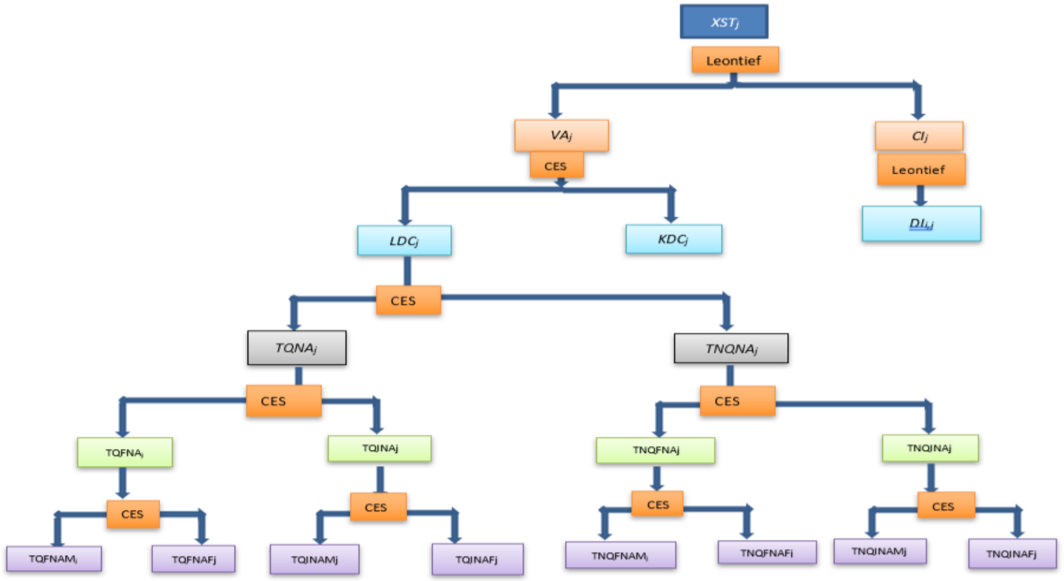
Graph 1: Structure of production in the agricultural sector



Source: The authors

Contrary to the agricultural sector, the level of skills of the workers is also taken into account in the non-agricultural sector.

Graph 2: Structure of production in the non-agricultural sector



Source: The authors

Taking climate change into consideration and the use of fertilisers as an adaptation measure is based on the study by Sawadogo et al. (2020). Indeed, they model the value added (VA_{agr}) of the agricultural sector by integrating a component that is dependent on climate change according to the following specification:

$$VA_{agr} = B_{agr}^{VA}\left[\beta_{agr}^{VA} LDC_{agr}^{-\rho_{agr}^{VA}} + (1-\beta_{agr}^{VA}) KDC_{agr}^{-\rho_{agr}^{VA}}\right]^{-1/\rho_{agr}^{VA}} \qquad (1)$$

Where LDC_{agr} is the composite labour of the agricultural branch agr and KDC_{agr} is the composite capital of the same agricultural branch. $B_{agr,t}^{VA}$ is the productivity parameter. This parameter is subject on the one hand to climatic conditions, notably drought and rainfall, and on the other hand to the use of fertilisers. All these determine its value. The latter is given by the following equation:

$$B_{agr}^{VA} = B_{agr}^{VA}\left(1 - clim_{agr}\right)(1 + fert_{agr}) \qquad (2)$$

Where $clim_{agr}$ is the climate change parameter and $fert_{agr}$. that of fertilizer use. For the same agricultural branch of activity, these parameters may vary from one AEZ to another.

The parameters $clim_{agr}$ are estimated from econometric models inspired by the studies of Belloumi (2014) conducted on Eastern and Southern African countries and Yobom (2020) conducted on 12 countries in the Sahel zone. The model is specified by a production function which is explained by climatic factors and economic inputs. More specifically, the model is written as follows:

$$Y_i = f(CC, L_i, F_i, A_i, K_i) \qquad (3)$$

With Y the index of production of product i, CC the indicators of climate change (temperature and precipitation) L, F, A and K respectively the labour, fertilisers, agricultural land and capital used for the production of product i. Agricultural land is expressed in hectares, labour is expressed as the total number of the economically active people, and fertilisers are given in thousands of tonnes.

In the literature, there are various specifications of the production function in relation to climate change (Barios et al., 2008; Belloumi, M., 2014). We chose Belloumi's (2014) because it enables the calculation of elasticities, based on the average values of the climate variables per AEZ after estimation. Indeed, the model to be estimated is explicitly written:

$$Y_t = \beta_0 * L_t^{\beta_1} * F_t^{\beta_2} * A_t^{\beta_3} * K_t^{\beta_4} * e^{\varepsilon_t} * e^{\beta_5 R_t + \beta_7 T_t} \qquad (4)$$

Changing this equation to the logarithm, we obtain the following specification:

$$\ln Y_t = \beta_0 + \beta_1 lnL_t + \beta_2 lnF_t + \beta_3 lnA_t + \beta_4 lnK_t + \beta_5 R_t + \beta_6 T_t \qquad (5)$$

T and R are the climate change variables representing respectively average temperatures expressed in °C per year and average precipitation expressed in mm per annum.

Elasticities are therefore calculated as follows:

$$E\left(\frac{dY/Y}{dR/R}\right) = \beta_5 * E(R) \qquad (6)$$

$$E\left(\frac{dY/Y}{dT/T}\right) = \beta_6 * E(T) \qquad (7)$$

The elasticities per AEZ are then calculated by applying the average temperature and precipitation of each zone. The estimates in equation (5) are made for the 13 agricultural products featured in the SAM by the ARDL approach, proposed by Pesaran et al. These estimates are made using data from FAOSTAT, the World Development Indicators (WDI) and the Climate Change Knowledge Portal. The reasons for the choice of this method, the various tests that were carried out and the results of the estimates and their analysis are presented in Appendix 8.2. The variations in agricultural crop yields as a result of climate change, calculated from these results, are presented in the table 1.

The optimistic scenario corresponds to the projection of fairly small changes in climate change parameters based on available information, while the pessimistic scenario corresponds to the projection of fairly large changes in these parameters.

<u>Table 1</u>: Variations in agricultural crop yields as a result of climate change (%)

Agricultural products by AEZ	Optimistic	Pessimistic
SSZ-Corn	-1.4	-6.5
HZS-BFZ-Corn	-2.5	-9.0
MSZ-Corn	-2.3	-7.6
MZ-Corn	-3.1	-11.9
SSZ-Millet and Sorghum	-5.7	-27.5
MSZ-Millet and Sorghum	-9.3	-31.1
SSZ-Rice	-7.8	-8.2
HSZ-BFZ-Rice	-10.5	-10.9
MSZ-Rice	-12.6	-13.0
MZ-Rice	-11.0	-11.4
SSZ-Other cereals	-7.7	-37.0
SSZ-Tubers	-16.6	-23.7
HSZ-BFZ-Tubers	-31.0	-34.6
MSZ-Tubers	-27.8	-29.9
MZ-Tubers	-28.7	-28.8
SSZ-Bananas	-0.1	-0.5
HSZ-BFZ-Bananas	-0.2	-0.7
MSZ-Bananas	-0.2	-0.6
MZ-Bananas	-0.2	-0.9
SSZ-Oilseeds	-11.6	-18.8
HSZ-BFZ Oilseeds	-21.8	-28.9
MSZ-Oilseeds	-19.5	-26.6

Agricultural products by AEZ	**Optimistic**	**Pessimistic**
MZ-Oilseeds	-26.4	-33.5
SSZ-Cottonseed and ginning products	3.2	15.2
SSZ-Fruit	2.4	11.4
HSZ-BFZ Fruit	3.6	12.6
MSZ-Fruit	4.6	15.4
MZ-Fruit	9.3	35.8
SSZ-Vegetables and ornamental flowers	-0.9	-4.3
HSZ-BFZ-Vegetables and ornamental flowers	-1.7	-5.9
MSZ-Vegetables and Ornamental flowers	-1.5	-5.0
MZ- Vegetables and Ornamental flowers	-2.0	-7.8
HSZ-BFZ-Cocoa bean, dried	4.8	17.1
MSZ-Cocoa bean, dried	4.3	14.4
MZ-Cocoa bean, dried	5.8	22.5
HSZ-BFZ-Sun-dried coffee and tea	-10.2	-36.1
MSZ-Sun-dried coffee and tea	-10.6	-35.4
MZ-Sun-dried coffee and tea	-10.5	-40.5
SSZ-Other agricultural products	-1.0	-4.8
HSZ-BFZ-Other agricultural products	-1.9	-6.6
MSZ-Other agricultural products	-1.7	-5.6
MZ-Other agricultural products	-2.3	-8.7

Source: Authors' estimates

The above values show that climate shocks have a negative impact on almost all the selected products except cotton, fruit and cocoa beans. The negative impact of climate shocks on the yields of corn, millet/sorghum, and oilseeds is consistent with the findings of Thornton et al. (2011), Shlenker and Lobell (2010), Thomas and Rosegrand (2015). The negative impact on rice yields is contrary to the findings of Thomas and Rosegrand (2015). The positive impact on cotton may be explained by the fact that cotton is one of the plants that can withstand climate change due to the carbon dioxide fertilising effect (Institute for Research and Development, 2022). The study also states that this fertilising effect is more than sufficient to compensate for the other impacts of climate change on the crop. On the whole, these results are consistent with the findings of work carried out in other sub-Saharan African countries. These include the work by Belloumi (2014) and Yobom (2020). The only difference is the amplitude of the shocks.

As regards the parameter $fert_{agr},$, the econometric models above also enable the elasticities of agricultural production of different crops with respect to fertilisers to be obtained. These elasticities can then be used to calculate variations in agricultural crop yields following an increase in the quantities of fertiliser used. A simulation with the CGE model makes it possible to estimate an increase in the quantities of fertiliser used, as a result of subsidising fertiliser prices by an equivalent 25% reduction in subsidies on oil prices. This then allows, using the elasticities obtained from the econometric models, to calculate the variations in agricultural crop yields resulting from this fertiliser price subsidy.

The resulting variations in agricultural yields are as follows:

Table 2: Variations in agricultural crop yields as a result of fertiliser use (%)

Agricultural products	Variations in crop yields (%)
Corn	0.2
Rice	0.7
Millet/sorghum	1.9
Other cereals	1.0
Fruit	2.3
Vegetables	1.0
Oilseeds	1.0
Coffee and tea	0.5
Cocoa beans	0.9
Bananas	1.2
Tubers	0.1
Cotton	4.5
Other products	0.9

Sources: Authors' estimates

The household account is disaggregated into four groups, according to the gender of the household head and the area of residence. The model assumes that households maximise their utility under income constraints according to a Stone-Geary function, which assumes minimum consumption for each commodity in the economy (Wamadini et al., 2019). Households receive income from labour and capital as well as from various transfers from the government and the rest of the world. They pay their taxes and the remaining disposable income is divided between consumption and savings. Firm's income is comprised of capital income as well as transfers from other institutional sectors. They pay taxes to the government, pay dividends to various institutions and save the remainder. Government income is the sum of taxes paid by the different institutional sectors, direct and indirect taxes on products and production as well as transfers from the rest of the world and a share of capital income. The government makes transfers to other institutional sectors and saves the remainder.

The income of the rest of the world is generated from sales on the Cameroonian market as well as transfers from other institutions and some capital income. These purchase commodities and make transfers to other institutional sectors. The difference between the income and expenditure of the rest of the world corresponds to the current account balance. The relationship between the rest of the world and the domestic economy is also characterised by the supply and demand of goods. From the supply perspective, domestic production is divided between that sold locally and that exported, according to a constant elasticity of substitution (CES) function. Domestic economic agents have the choice between locally produced goods and imported goods. This decision depends on the relative prices of local and imported goods as well as the elasticities of substitution between the two goods. As regards the closure of the model, we assume that the exchange rate is the numeraire. Relative prices allow for the adjustment of supply and demand of goods. Considering that Cameroon is a small country whose prices do not influence world prices, we consider that both import and export prices are fixed in the model. The supply of capital is equal to the demand for capital. The current account balance is exogenous.

In Cameroon, the agricultural sector is highly informal. Indeed, workers in this sector who cannot find employment in the formal sector become self-employed, work on family farms, or work as employees on small informal farms. Therefore, it is assumed that in the agricultural labour market (in a given AEZ), the supply of formal labour may differ from the demand for both men and women. The resulting unemployment rate is determined by a wage-curve function, i.e. it is inversely related to the real wage rate: the higher the real wage rate, the lower the unemployment rate and, conversely, the lower the real wage rate, the higher the unemployment rate (Blanchflower and Oswald, 2005). Formal workers who have not been able to find a job in the labour market will join the supply of informal workers in the same zone. It is assumed that workers can migrate freely from one branch of activity to another, but remain in the same AEZ (zone-specific labour market).

Concerning the non-agricultural labour market, it is also assumed that the supply of formal labour may differ from the demand, for both skilled and unskilled workers, irrespective of their gender. The unemployment rate similarly follows a wage-curve function. Skilled and unskilled workers who have not found a job in the formal sector cannot move to another branch of activity, but will be added to the supply of informal workers in the same branch of activity.

4.2 Food security analysis

To analyse the impact on food security, we consider the three abovementioned FAO indicators namely, availability, accessibility and stability. The availability indicator used is national production destined for the domestic market. Following (Boccanfuso et al., 2008; Cockburn et al., 2008, Escalante and Maisonnave, 2022), accessibility is measured by the real household budget allocated to the consumption of agricultural products, as this integrates aspects of income and price and allows the gender specificity of households to be taken into account. As for stability, we address it using the vulnerability indicator, which is the ratio of imports to the quantities of the various agricultural products available on the domestic market. This indicator makes it possible to evaluate whether a possible decline in the domestic production of some of these agricultural products is offset by an increase in the importation of these products, thereby leading to an increase in food dependency on the external market. Hereafter, rather than referring to stability, we will refer to vulnerability.

5. Application and results of the simulations

5.1 The simulation scenarios

This first scenario tested in this study is the impact of climate change on the agricultural sector and on food security. This is our baseline scenario, and it is implemented as outlined in the methodology. Next, two climate change adaptation policy scenarios are simulated. The first involves a policy of subsidising the price of agricultural fertilisers, with two funding options. Firstly through the public deficit (SIM1) and secondly, by an equivalent 25% reduction in subsidies on oil prices with exogeneity of the public deficit (SIM2). Several factors justify the simulation of this kind of adaptation policy in this paper.

Indeed, the policy of subsidising agricultural inputs has been retained and implemented by the Cameroonian government through the ministry in charge of agriculture for several years (MINADE, 2019). Also, according to UN Women (2019), differences in agricultural productivity between men and women, particularly in Africa, are caused by women's unequal access to agricultural inputs. Furthermore, several studies stress the fact that the state subsidy on petroleum products is not pro-poor, and benefits wealthy households in urban areas more (Zamo, 2012; Nguetse et al. (2018)).

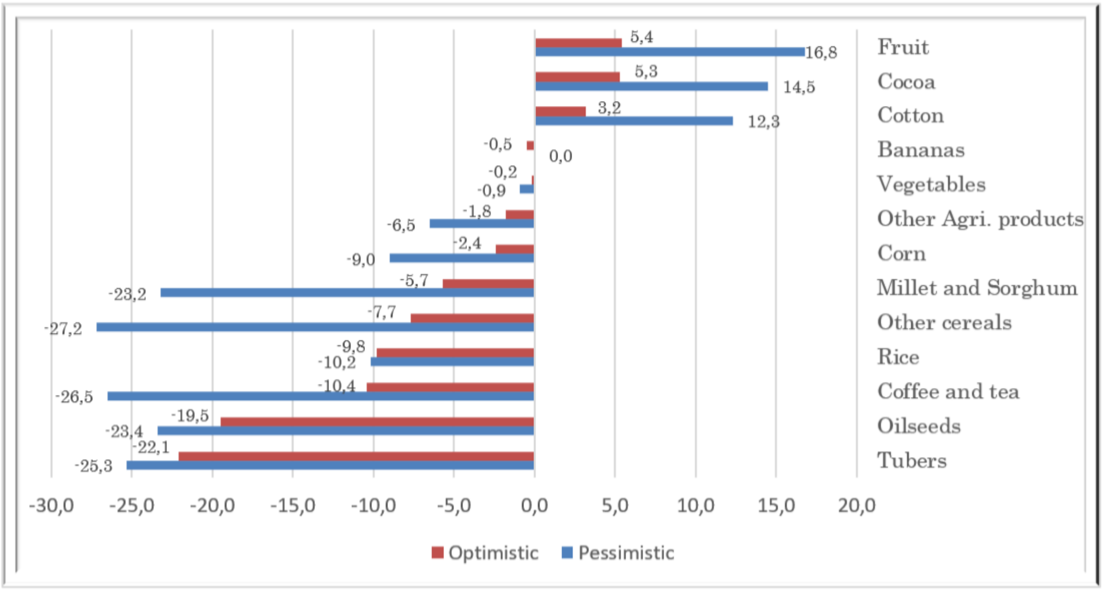
5.2 Results of the simulations

5.2.1. Analysis of the impact on the economy as a whole

The results of the simulations show that the decline in agricultural productivity caused by climate shocks affects all agricultural branches (Graph3. This result is quite consistent with those reported in the literature (Sawadogo et al (2021); Bosello et al., 2017). The magnitude of the impact of climate change varies from one agricultural branch to another and from one scenario to another, depending on the sensitivity of each branch to climate change. Therefore, regarding the optimistic scenario, the most impacted agricultural products are tubers (-22.1%), oilseeds (-19.5%), coffee and tea (-10.4%) rice (-10.2%), cocoa (-10.4%) and corn (-8.9%).

The negative shock on bananas gives mixed results, as there is a slight increase (0.1%) in the value added of this product. Other increases are observed for cotton (3.2%), cocoa (5.3%) and fruit (5.4%). These increases are in line with the shock. As regards the pessimistic scenario, the trend of the impact is the same for all crops except for bananas, whose value becomes negative (-0.5%). The effect differential between the optimistic and pessimistic scenarios is relatively small for rice, tubers and oilseeds (at most 20%[3]) but very high for the other products.

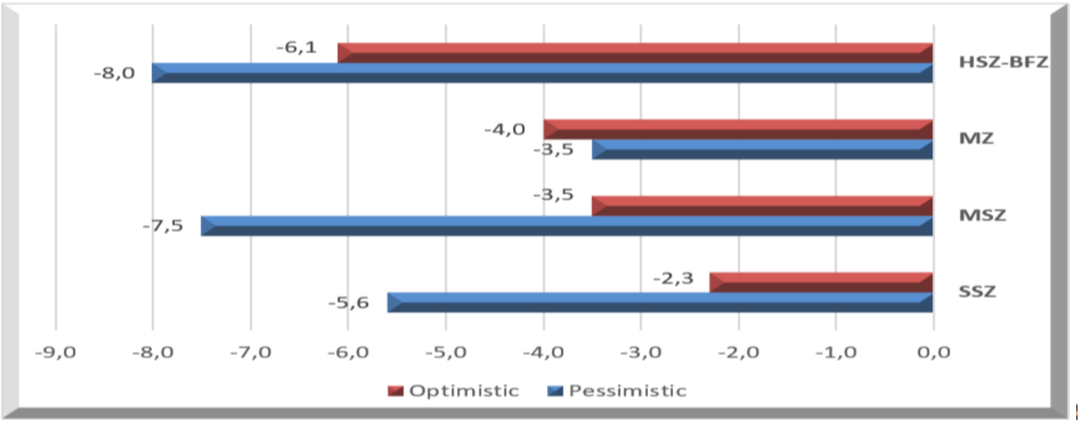
Graph 3: Impact of climate change on agricultural value added (%)



Source: The authors' simulations

An analysis by AEZ shows that in the agricultural sector, the high savannah and bimodal forest zone (HSZ-BFZ) is the zone most affected by climate shocks regardless of the scenario tested (-6.1% optimistic and -8.0% pessimistic). The second most affected zone under the optimistic scenario is the mangrove zone (MZ) with -4.0% recorded and the moist savannah zone (MSZ) under the pessimistic one (-7.5%). The least affected zone under the optimistic scenario is the Sudano-Sahelian one where -2.5 was recorded and under the pessimistic one, the mangrove zone (-3.5%).

Graph 4: Impact of climate change on agricultural value added by AEZ (%)



Source: The authors' simulations

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[3] The method of calculation is (pessimistic scenario variation/optimistic scenario variation)-1.

The decline in value added in the various agricultural branches leads to an equivalent decline in production, notably for consumption-intensive products such as tubers, oilseeds, rice and corn. This decline in production leads to a decline in the demand for labour in both the formal and informal sectors. Closer examination of the optimistic scenario shows that in the formal sector, this decline is much more pronounced for women in the SSZ and MSZ zones (-0.4% versus -0.1% for men and -0.4% versus -0.2% for men). By contrast, in the HSZ and BFZ zones, the decline in labour demand affects men more than women (-3.9% versus -3.3%). In the mangrove zone, the demand for labour increases in the formal sector though more significantly for men (0.8% compared to 0.2% for women).

In the informal sector, the decline is more pronounced for men in the MZ zone (-3.8% versus -0.3% for women). Formal workers having lost their jobs in the SSZ, HSZ-BFZ and MSZ zones move to the informal sector. Consequently, there is an increase in informal work in these zones. Under the pessimistic scenario, the same trend is observed but with greater variations. Moreover, in all zones with the exception of the mangrove zone (MZ), the differences in variation between the two scenarios do not exceed 0.3%.

<u>Table 3</u>: Impact of climate change on the demand for agricultural labour by AEZ (%)

	Optimistic				**Pessimistic**			
Zone	**FFAL**	**FMAL**	**IFAL**	**IMAL**	**FFAL**	**FMAL**	**IFAL**	**IMAL**
HSZ-BFZ	-3.3	-3.9	3.7	2.5	-3.4	-4.0	3.8	2.6
MZ	0.2	0.8	-0.3	-3.8	0.6	1.1	-0.8	-5.6
MSZ	-0.4	-0.2	0.1	0.0	-0.7	-0.3	0.1	0.1
SSZ	-0.4	-0.1	0.5	1.2	-0.5	-0.1	0.6	1.2

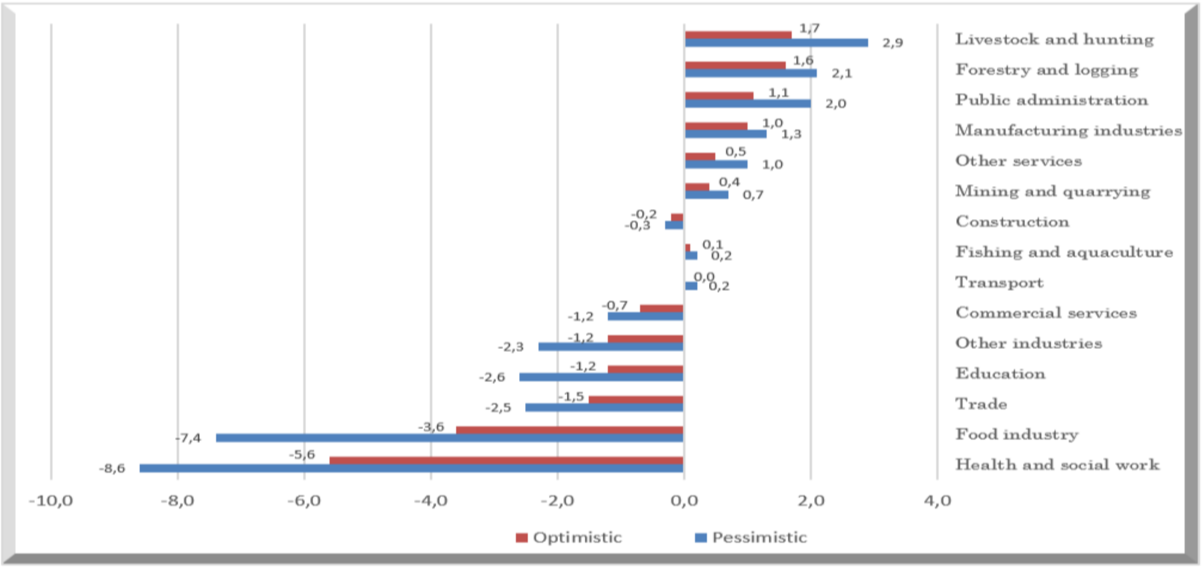
Source: The authors' simulations

FFAL=Formal Female Agricultural Labour ; FMAL=Formal Male Agricultural Labour ; IFAL=Informal Female Agricultural Labour IMAL=Informal Male Agricultural Labour

The effects of climate change are transmitted to the non-agricultural branches mainly through the intermediate consumption channel. The impact trend is the same regardless of the scenario, with higher amplitudes observed for the pessimistic scenario. Value added improves significantly in public administration (1.1% and 2.0%), livestock and hunting (1.7% and 2.9%) and forestry (1.6% and 2.1%).

However, it declines significantly in the health and social work branch (-5.6% and -8.6%), the food industry (-7.4% and -3.6%), trade (-1.5% and -2.5%) and education (-1.2% and -2.6%). There is also a decline in the value added of the construction sector, which is partly explained by the fact that when household incomes fall, there is less investment in construction. Consequently, there will either be an increase or a decrease in the demand for labour in response to an increase or decrease in value added in the non-agricultural branches.

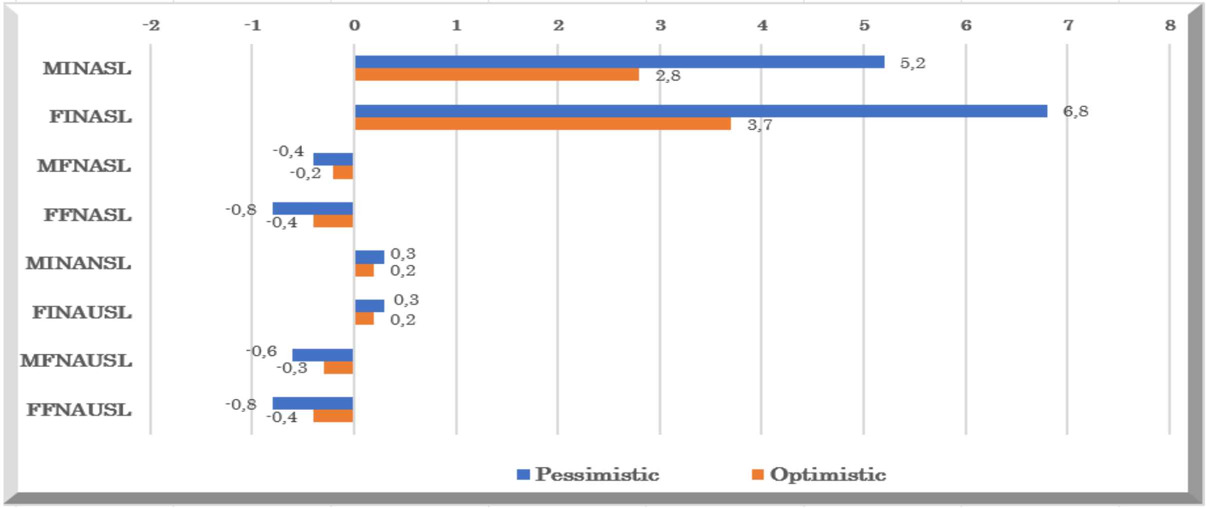
Graph 5: Impact of climate change on the value added of non-agricultural branches (%)



Source: The authors' simulations

Climate change has a negative effect on workers in the formal non-agricultural branches under both scenarios. Reduced production means formal firms are required to hire less skilled and unskilled workers. Nevertheless, female workers are the most affected, irrespective of their level of skills and the climate change scenario (for the optimistic scenario, -0.4% for skilled female formal workers versus -0.2% for skilled male formal workers and -0.4% for unskilled female workers versus -0.3% for unskilled male workers). Formal workers who could not find work move to the informal sphere. As a result, there is an increase in informal work regardless of the level of skills.

Graph 6: Impact of climate change on non-agricultural labour demand (%)



Source: The authors' simulations

MINASL = Male informal non-agricultural skilled labour ; FINASL = Female informal non-agricultural skilled labour
MFNASL = Male formal non-agricultural skilled labour ; FFNASL = Female formal non-agricultural skilled labour
MINANSL = Male informal non-agricultural unskilled labour ; FINAUSL = Female informal non-agricultural unskilled labour
MFNAUSL = Male formal non-agricultural unskilled labour ; FFNAUSL = Female formal non-agricultural unskilled labour

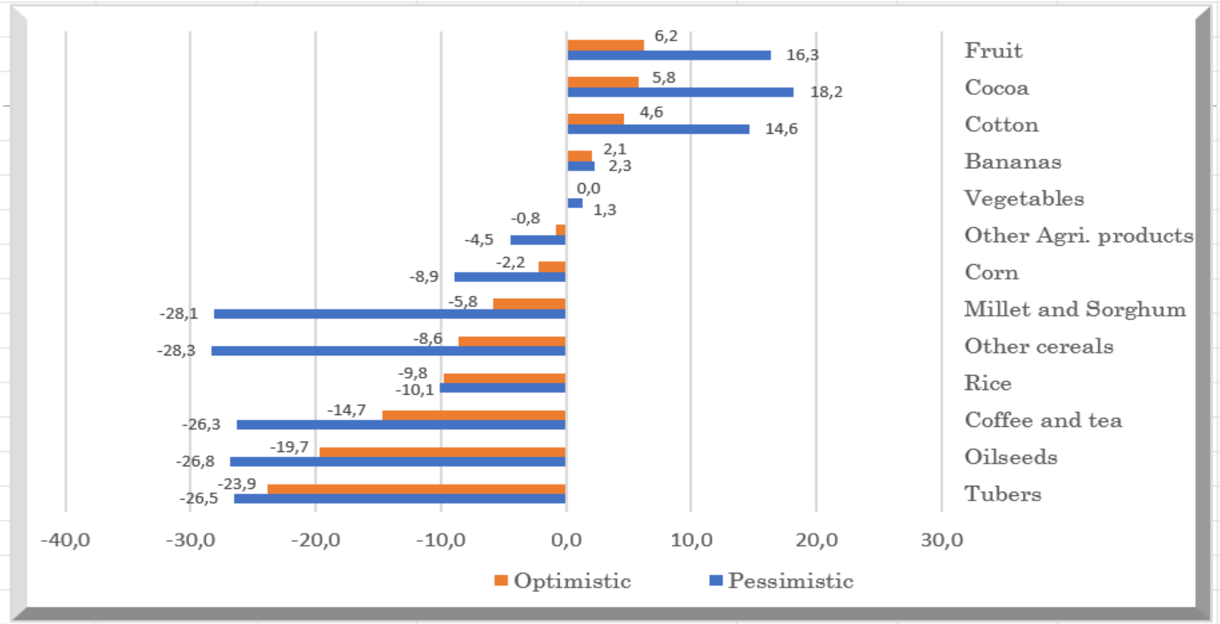
At the macroeconomic level, the simulation results reveal a -0.7% decline in real gross fixed capital formation (GFCF) and a -0.8% decline in real GDP.

5.2.2 Analysis of the impact on food security

- ***Impact on availability***

For the 'availability' pillar of food security, the impact of climate change is measured here by the variation in the production sold on the domestic market of the different agricultural products and the variation in imports. Production destined for the domestic economy declines for those agricultural products which are negatively affected by climate change, the magnitude of the decline being more pronounced for the pessimistic scenario. Assuming the optimistic scenario occurs, the products whose availability will be most affected are tubers (-23.9%), oilseeds (-19.7%), coffee and tea (-14.7%) and rice (-9.8%). On the other hand, assuming the pessimistic scenario comes to pass, the products that will suffer the greatest decline in available quantities are other cereals (-28.3%) and millet and sorghum (-28.1%). The products on which climate change has a positive effect and which are more available as a result of the climate shock, regardless of the scenario that occurs, are bananas, cotton, fruits and cocoa.

Graph 7: Impact of climate change on the availability of agricultural products on the domestic market (%)

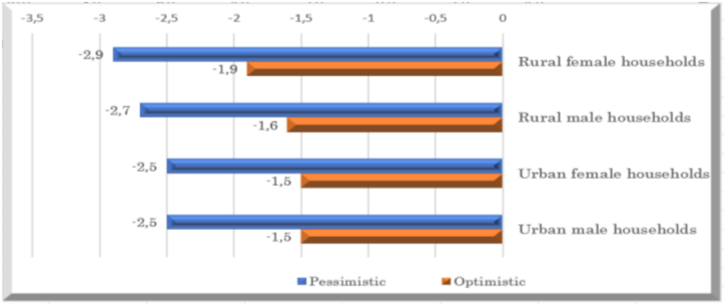


Source: The authors' simulations

- ***Impact on accessibility***

The effect of climate change on the 'accessibility' pillar of food security is measured here by the change in the real consumption budget of households. The simulations reveal that climate shocks have a negative impact on the real consumption budget of all categories of households regardless of the scenario with larger impacts occurring under the pessimistic scenario.

Graph 8: Impact of climate change on the real household consumption budget for agricultural products by category (%)

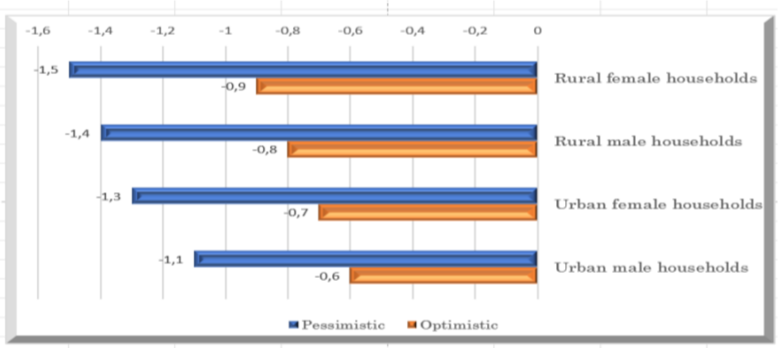


Source: The authors' simulation

The impact is more pronounced for rural households, especially those headed by women (-1.9% compared to -1.6% for men under the optimistic scenario). The impact trend of climate change on urban household budgets is the same between those headed by women and those headed by men under both scenarios, but the pessimistic scenario affects both households to a greater extent (-1.5% for the optimistic scenario and -2.5% for the pessimistic one). The decline in the real consumption budget can be explained by the decline in disposable incomes for all household categories and by the increase in the price index, particularly for agricultural products (it increases by 3.2% for the optimistic scenario and by 6.2% for the pessimistic one).

The decline in household disposable income is largely due to the negative impact of climate shocks on household wages. In fact, wages decline for all household categories irrespective of the scenario. However, the decline is more pronounced among female-headed households regardless of the area of residence (-0.9% optimistic and -1.5% pessimistic in rural areas and -0.7% optimistic and -1.3% pessimistic in urban areas).

Graph 9: Impact of climate change on household wages by household category (%)

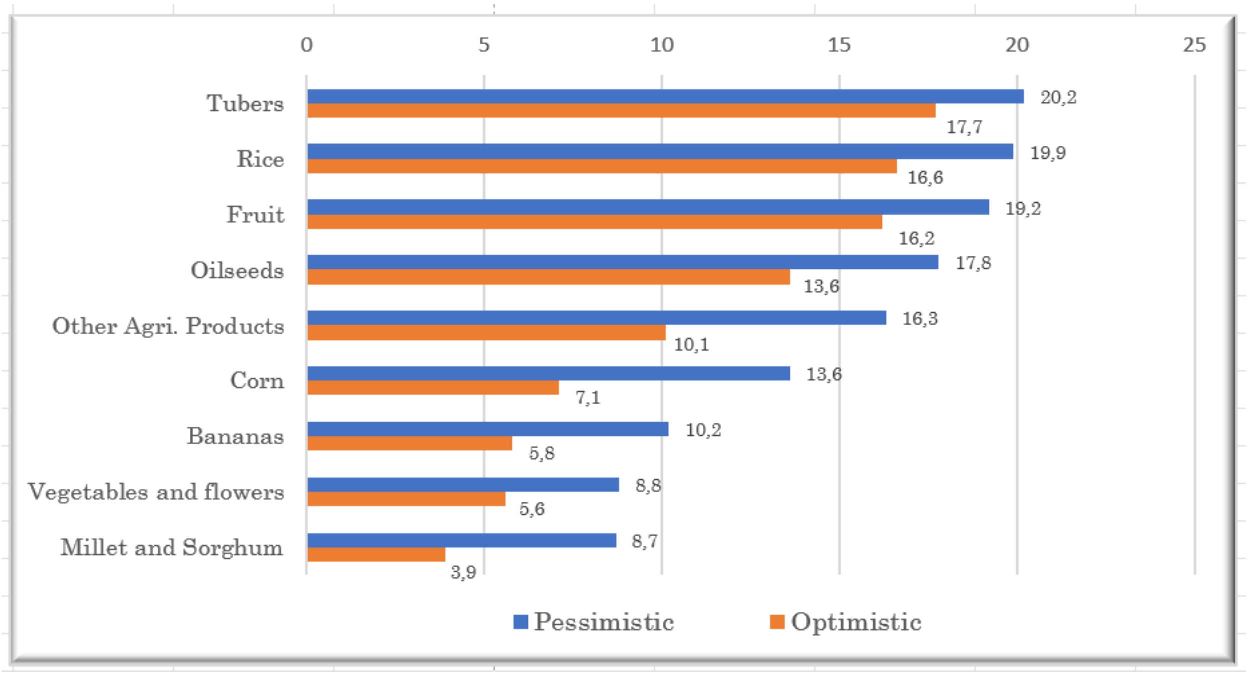


Source: The authors' simulations

- ***Impact on vulnerability***

The results of the simulations also show an increase in imports of all agricultural products, greater than the decrease in the quantities demanded. This increase is also more significant for consumer products that have seen a decline in the quantities demanded (rice, oilseeds, corn, tubers, fruits, millet and sorghum, etc.). The trend is the same regardless of the scenario envisaged.

Graph 10: Impact of climate change on the import of agricultural products (%)



Source: The authors' simulations

Thus, imports seem to offset the decline in the domestic production of agricultural products. Indeed, when we look at the ratio of imports to domestic demand, we notice that it increases for all products for which there is an increase in imports following climate shocks (Table 4). Therefore, with regard to the consumption of agricultural products, climate change tends to make the country more dependent on foreign imports which makes it more vulnerable.

Table 4: Impact of climate change on the country's food vulnerability (%)

Products	**Imports/Quantities demanded (%)**		
	Base	**Optimistic**	**Pessimistic**
Bananas	43.5	46.6	47.9
Vegetables	33.0	35.1	36.5
Millet and Sorghum	30.5	32.0	35.6
Oilseeds	29.4	34.0	37.0
Tubers	27.0	32.5	34.2
Corn	24.5	26.6	28.5
Fruit	17.2	20.0	20.2
Rice	6.7	7.9	8.6
Other agricultural products	2.9	3.2	3.7

Source: The authors' simulations

5.2.2. Comparative analysis of the impacts of SIM1 and SIM2

- ***Comparative analysis of the impact on the economy as a whole***

Subsidising fertiliser prices, which result in improved factor productivity, allow agricultural branches to produce more, regardless of whether this policy is financed by budget deficits or by reducing subsidies on oil products. It can be seen that this policy leads to almost the same effects on the value added of the agricultural branches, although the positive effect is slightly greater when it is financed through the public deficit. Indeed, the increase in prices following the reduction in the subsidy of petroleum products has a negative impact on certain industrial and service branches that depend on petroleum products, including transport, trade and the agri-food industries, which use petroleum products. Thus, indirectly, it ends up having a small impact on the agricultural branches, under the assumption that there is no Ricardian equivalence.

Moreover, under all climate change scenarios, improving factor productivity through the use of fertilisers reduces the effect of climate change on the value added of the branches when it is negative and increases it when it is positive. This policy manages to reverse the trend for certain products for which the effects were negative. These are bananas (from -0.5% to 0.8% for the pessimistic scenario) and vegetables (from -0.2% and -0.9% to 0.8% and 0.3% for the optimistic and pessimistic scenarios respectively).

Table 5: Comparison of impacts on value-added (%)

Products	**SIM0**		**SIM1**		**SIM2**	
	Optimistic	**Pessimistic**	**Optimistic**	**Pessimistic**	**Optimistic**	**Pessimistic**
Other cereals	-7,7	-27.2	-6.7	-25.1	-6.8	-25.3
Other agricultural products	-1.8	-6.5	-0.9	-5.7	-0.9	-5.7
Bananas	0.1	-0.5	1.4	0.8	1.3	0.9
Coffee and tea	-10.4	-26.5	-10.0	-23.5	-10.0	-23.5
Cotton	3.2	12.3	6.8	19.4	6.7	19.5
Cocoa	5.3	14.5	6.3	21.0	6.3	21.0
Fruit	5.4	16.8	7.9	22.6	7.9	22.6
Vegetables	-0.2	-0.9	0.8	0.3	0.8	0.3
Corn	-2.4	-9.0	-2.2	-9.0	-2.2	-9.0
Millet and Sorghum	-5.7	-23.2	-4.0	-22.1	-4.0	-22.1
Oilseeds	-19.5	-23.4	-18.6	-21.0	-18.8	-21.2
Rice	-9.8	-10.2	-9.2	-9.6	-9.2	-9.6
Tubers	-22.1	-25.3	-20.2	-22.2	-20.4	-22.4

Source: The authors' simulations

Improved production leads to formal sector firms demanding additional workers irrespective of the climate change scenario. As a result, the negative impact of the climate change shock on the demand for formal male and female agricultural workers is declining in all areas, and in particular in the SSZ, where the downward trend is reversed. Consequently, there is a decrease in the number of both female and male workers in the informal agricultural sector. As was the case for value added, the impact is slightly more positive when the fertiliser price subsidy policy is financed by the public deficit.

Table 6: Comparison of the impacts on agricultural labour demand by AEZ (%)

Simulation	Scenario	Type of labour	HSZ-BFZ	MZ	MSZ	SSZ
SIM0	Optimistic	FFAL	-3.3	0.2	-0.4	-0.4
		FMAL	-3.9	0.8	-0.2	-0.1
		IFAL	3.7	-0.3	0.1	0.5
		IMAL	2.5	-3.8	0.0	1.2
	Pessimistic	FFAL	-3.4	0.6	-0.7	-0.5
		FMAL	-4.0	1.1	-0.3	-0.1
		IFAL	3.8	-0.8	0.1	0.6
		IMAL	2.6	-5.6	0.1	1.2
SIM1	Optimistic	FFAL	-3.1	0.4	-0.4	0.8
		FMAL	-3.7	0.9	-0.2	0.3
		IFAL	3.5	-0.6	0.0	-1.0
		IMAL	2.4	-4.5	0.0	-5.5
	Pessimistic	FFAL	-3.2	0.7	-0.6	0.8
		FMAL	-3.9	1.2	-0.3	0.4
		IFAL	3.6	-1.0	0.1	-1.0
		IMAL	2.5	-6.1	0.1	-6.1
SIM2	Optimistic	FFAL	-3.2	0.3	-0.5	0.7
		FMAL	-3.9	0.8	-0.3	0.2
		IFAL	3.7	-0.4	0.1	-0.4
		IMAL	2.6	-4.0	0.1	-3.1
	Pessimistic	FFAL	-3.5	0.5	-0.9	-0.2
		FMAL	-4.2	1.1	-0.5	0.0
		IFAL	3.9	-0.7	0.1	0.2
		IMAL	2.7	-5.5	0.1	-0.8

Source : The authors' simulations

FFAL = Formal Female Agricultural Labour; FMAL=Formal Male Agricultural Labour; IFAL=Informal Female Agricultural Labour ; IMAL=Informal Male Agricultural Labour

a) *Comparative analysis of the impact on food security*

- ***Impact on availability***

Improving productivity through the use of fertilisers reduces the magnitude of the effect of climate change on the domestic production of agricultural products, thereby improving the availability of these products on the domestic market. This applies to products that are frequently consumed by households, such as rice, corn, millet, sorghum and oilseeds. As seen with value added, the positive effect of this policy on the consequences of climate change is greatest when it is financed by budget deficits.

Table 7: Comparison of the impacts on the domestic supply of agricultural products to the domestic market (%)

Products	SIM0		SIM1		SIM2	
	Optimistic	Pessimistic	Optimistic	Pessimistic	Optimistic	Pessimistic
Other cereals	-8.6	-28.3	-7.5	-27.6	-7.6	-27.7
Other agricultural products	-0.8	-4.5	-0.1	-3.8	-0.1	-3.8
Bananas	2.1	2.3	3.3	3.5	3.3	3.4
Coffee and tea	-14.7	-26.3	-13.9	-25.2	-13.7	-25.8
Cotton	4.6	14.6	5.7	16.8	5.8	16.7
Cocoa	6.2	16.3	7.2	16.9	6.5	16.2
Fruit	5.8	18.2	7.2	20.9	7.3	19.9
Vegetables	0.0	1.3	1.1	2.4	1.0	2.3
Corn	-2.2	-8.9	-2.0	-8.6	-2.1	-8.7
Millet and Sorghum	-5.8	-28.1	-4.0	-26.2	-4.1	-26.7
Oilseeds	-19.7	-26.8	-18.1	-26.1	-18.9	-26.1
Rice	-9.8	-10.1	-9.0	-9.6	-9.2	-9.6
Tubers	-23.9	-26.5	-22.1	-24.9	-22.8	-25.5

Source: The authors' simulations

- ***Impact on accessibility***

The increase in demand for workers in the formal agricultural sector as a result of fertiliser price subsidies leads to higher incomes for the different household categories, and therefore to an increase in the amount of income spent on the consumption of agricultural products, irrespective of the climate change scenario. This helps to soften the impact of climate change on real household budgets allocated to the consumption of agricultural products, especially for rural female-headed households.

Table 8: Comparison of the impact on the real household consumption budget of agricultural products by household category (%)

Categories of households	SIM0		SIM1		SIM2	
	Optimistic	Pessimistic	Optimistic	Pessimistic	Optimistic	Pessimistic
Urban male households	-1.52	-2.46	-1.26	-2.31	-1.33	-2.40
Urban female households	-1.53	-2.47	-1.07	-2.22	-1.12	-2.29
Rural male households	-1.64	-2.69	-1.19	-1.95	-1.24	-2.03
Rural female households	-1.90	-2.94	-1.28	-2.45	-1.36	-2.55

Source: The authors' simulations

- ***Impact on vulnerability***

The vulnerability of the economy to agricultural imports declines following the implementation of the fertiliser price subsidy policy under both climate change scenarios. Indeed, increased production enables a better domestic supply-response to demand for all agricultural products, thereby reducing the economy's dependence on imported agricultural products. The economy is slightly less dependent on imported agricultural products when the fertiliser policy is financed by a budget deficit. Indeed, this method of financing is a pure stabilisation policy, but does not increase the risk of transition (acceleration of the devaluation of hydrocarbon assets), as opposed to financing it through a reduction in oil price subsidies.

Table 9: Comparison of the impact on the country's food vulnerability (%)

Products	Imports/Quantities demanded (%)						
	Base	SIM0		SIM1		SIM2	
		Optimistic	Pessimistic	Optimistic	Pessimistic	Optimistic	Pessimistic
Bananas	43.5	46.6	47.9	46.3	47.6	46.3	47.6
Vegetables	33	35.1	36.5	34.7	36.1	34.8	36.1
Millet and Sorghum	30.5	32	35.6	31.5	35.1	31.6	35.1
Oilseeds	29.4	34	37.0	33.6	36.6	33.6	36.6
Tubers	27	32.5	34.2	32.1	33.8	32.1	33.8
Corn	24.5	26.6	28.5	26.4	28.3	26.4	28.3
Fruit	17.2	20	20.2	19.5	19.7	19.4	19.6
Rice	6.7	7.9	8.6	7.7	8.5	7.7	8.5
Other agricultural products	2.9	3.2	3.7	3.2	3.8	3.2	3.8

Source: The authors' simulations

6. Conclusions and policy implications

The aim of this study was to assess the gender-differentiated impact of public climate change adaptation policies on food security in Cameroon. The issue of climate change is now one of the international community's major concerns, not to mention that of the Cameroonian government, which takes it into account in all its strategic plans, notably in the new National Development Strategy 2020-2030 (NDS30), as well as in its Rural Sector Development Strategy. This sector, whose production largely ensures the countries food security, is also the one most exposed to climate change. It employs nearly 80% of the working population, more than 60% of which are women.

These women, who are more affected by income poverty and work more predominantly in informal employment, may be more affected by climate change. Using data from national accounts, major national surveys and the Ministry of Agriculture, a 2018 SAM was produced. This matrix was used as the foundation for the development of a CGE model, which was based on the static Pep 1-1 model. Econometric modelling allowed the impact of climate change on agricultural crop yields to be estimated for the various AEZs.

The results of the study show that the decline in yields of the various agricultural branches as a result of climate change reduces the value added of agriculture and of the other non-agricultural branches that depend on agricultural products. The magnitude of the impact of climate change on the value added of the agricultural branches differs from one AEZ to another, and worsens food insecurity in terms of availability, accessibility and vulnerability as defined by the FAO. Indeed, agricultural production declines, as does the household budget allocated to the consumption of agricultural products. This decline is more pronounced for female-headed households, especially those living in rural areas. The paper also highlights that in order to compensate for the decline in agricultural production, the Cameroonian economy resorts to importing the thus impacted high-consumption products, which increases the country's dependence on the outside world and makes it more vulnerable in terms of food security.

A policy of subsidising fertiliser prices was also found to mitigate the effects of climate change while reducing women's vulnerability to it. Effectively, this policy encourages greater consumption of fertiliser by formal agricultural firms, which in turn leads to an increased demand for labour by these firms, especially female labour. This will boost agricultural production on the one hand and improve household income devoted to the consumption of agricultural products on the other, particularly amongst rural households headed by women who are the most affected by climate change. Ultimately, the country's dependence on the outside world will diminish as imports decline.

Another observation is that when this policy of subsidising fertiliser prices is financed by a budget deficit, it has slightly better effects than when it is financed through a reduction in oil price subsidies. It should be noted, however, that an intensification in the use of fertilisers may eventually lead to a reduction in the marginal yields of the land and thereby increase the countries vulnerability to the climate problem.

7. References

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8. Annexe

8.1 Description of the Cameroonian economy according to the SAM

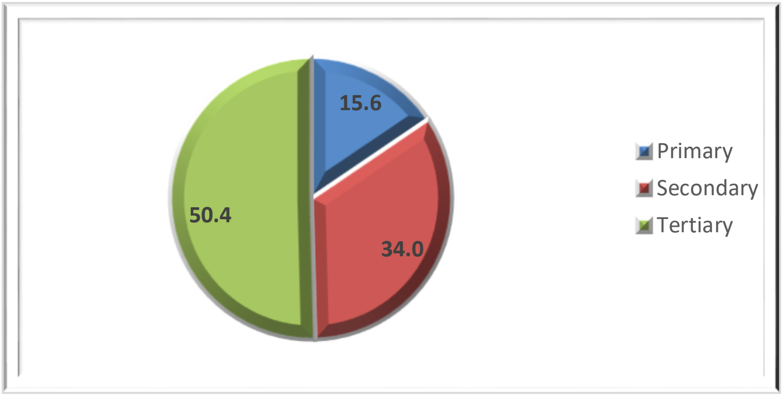
In this section, we present the Cameroonian economy using SAM data. The analysis begins with a presentation of the main components of production. Particular emphasis is placed on agricultural production in the AEZs. It continues with an analysis of the production factors of the branches of activity, with particular emphasis placed on the gender dimension. The analysis leads to the presentation of the elements of the household account.

8.1.1. Overall production

Production is mainly split between value added and intermediate consumption.

Value added is achieved through the activities of the primary, secondary and tertiary sectors. The primary sector contributes 15.6% to GDP. It is driven by agriculture (10.1%) and by forestry and logging (3.6%). The secondary sector represents 34.0% of gross domestic product (GDP). It is driven by the manufacturing industry (14.8%), construction (7.7%) and the agri-food industry (5.8%). As for the tertiary sector, it represents slightly more than half of the wealth created (50.4%). The largest contributors to GDP in this sector are wholesale and retail trade (9.8%), transport, storage and communication (9.4%) and market services (8.4%).

Graph A1: Contribution of the different sectors to the creation of wealth (%)



Source: 2018 SAM - Cameroon.

8.1.2. Agricultural production in AEZs

Agricultural production is differentiated by AEZ. The Sudano-Sahelian zone produces mainly millet and sorghum (37.3%), cotton (19.8%), vegetables (14.0%), oilseeds, especially peanuts (9.8%) and corn (8.6%). These products represent almost 90% of the total agricultural production in this area. Rice is also extensively grown here, which has a favourable climate and 40.3% of the production of this commodity comes from this zone. This zone is also home to the Society for the Expansion and Modernisation of Rice-growing (SEMRY), which is the main local rice producer. In the high savannah and bimodal forest zone, the main agricultural products are vegetables and pulses (25.0%), cocoa (15.0%), tubers (10.8%), corn (13.3%) and bananas (9.6%). These products represent 84.3% of the area's agricultural production. In the moist savannah zone, agricultural production is largely dominated by vegetables and pulses (49.6%), bananas (15.2%) and corn (7.4%). In the mangrove zone, agricultural production is mainly cocoa (22.3%), vegetables and pulses (18.8%), corn (13.8%), oilseeds (9.8%) and tubers (6.5%).

Table A1: Structure of agricultural production in the AEZs (in %)

Products	SSZ	HSZ-BFZ	MSZ	MZ
Corn	8.6	13.3	7.4	13.8
Millet and sorghum	37.3	0.0	0.3	0.0
Paddy rice	2.9	1.2	2.4	0.7
Other cereals	0.6	0.0	0.01	0.0
Tubers	1.7	10.8	2.8	6.5
Bananas	0.7	9.6	15.2	3.9
Oilseeds	9.8	0.7	3.9	9.8
Cotton	19.8	0.0	0.0	0.0
Fruit	0.3	4.7	2.4	4.0
Vegetables and pulses	14.0	25.0	49.6	18.8
Cocoa	0.0	15.1	3.8	22.3
Coffee and tea	0.0	2.8	4.6	2.1
Other agricultural products	4.2	7.1	7.9	8.2
Total	100.0	100.0	100.0	100.0

Source: 2018 SAM - Cameroon

8.1.3 The production factors in the different branches of activity

The structure of the branches of activity according to the different factors of production shows that the majority of them are capital intensive. This trend is more pronounced in the branches of the agricultural sector, which for the most part remunerate capital at a rate of at least 80% of its value added. It should be pointed out that the capital of the agricultural branches is largely made up of mixed income, particularly in the informal branches. Indeed, there are a very large number of individual entrepreneurs in these branches. The only labour-intensive branches are public administration (78.7%), education (80.1%), health and social work (97.0%) and other industries (84.4%).

Table A2: Structure of production factors by branch of activity (in %)

Branch of activity	Capital	Labour	Total	Male labour	Female labour	Total
Corn	99.7	0.3	100.0	51.8	48.2	100.0
Millet and sorghum	99.9	0.1	100.0	58.8	41.2	100.0
Paddy rice	99.5	0.5	100.0	56.5	43.5	100.0
Other cereals	99.9	0.1	100.0	50.0	50.0	100.0
Tubers	90.1	9.9	100.0	54.1	45.9	100.0
Bananas	81.6	18.4	100.0	89.6	10.4	100.0

Branch of activity	Capital	Labour	Total	Male labour	Female labour	Total
Oilseeds	97.4	2.6	100.0	63.2	36.8	100.0
Cotton	71.8	28.2	100.0	94.2	5.8	100.0
Fruit	99.7	0.3	100.0	57.3	42.7	100.0
Vegetables	98.6	1.4	100.0	42.0	58.0	100.0
Cocoa	93.5	6.5	100.0	84.3	15.7	100.0
Coffee and tea	98.7	1.3	100.0	82.6	17.4	100.0
Other agricultural products	99.4	0.6	100.0	67.4	32.6	100.0
Livestock and hunting products	87.3	12.7	100.0	57.0	43.0	100.0
Forestry and logging products	90.2	9.8	100.0	77.6	22.4	100.0
Fish and aquaculture products	99.6	0.4	100.0	64.8	35.2	100.0
Mining and quarrying	89.4	10.6	100.0	72.9	27.1	100.0
Food and beverage industry	75.5	24.5	100.0	63.6	36.4	100.0
Nitrogen products and fertilisers	87.0	13.0	100.0	69.0	31.0	100.0
Manufacturing industries	86.7	13.3	100.0	63.4	36.6	100.0
Other industries	15.6	84.4	100.0	60.5	39.5	100.0
Construction	67.8	32.2	100.0	68.4	31.6	100.0
Trade and repair and maintenance of vehicles	68.9	31.1	100.0	54.7	45.3	100.0
Transport. storage and communication	85.2	14.8	100.0	61.7	38.3	100.0
Market services	72.3	27.7	100.0	57.5	42.5	100.0
Public administration and social security	21.3	78.7	100.0	84.1	15.9	100.0
Education	19.9	80.1	100.0	53.8	46.2	100.0
Health and social work	3.0	97.0	100.0	51.3	48.7	100.0
Other services n.e.c.[4]	71.1	28.9	100.0	54.0	46.0	100.0

Source: 2018 SAM - Cameroon

Looking at the structure of labour compensation across the branches of activity, it appears that across all non-agricultural branches, wages paid to men are higher than those paid to women. Only in vegetables do women earn more than men in the agricultural branches (52.0% versus 48.0%). In Cameroon, women are more likely to work in low-paid jobs. In fact, 93.8% of employed women work in the informal sector compared to 87.5% of men (INS, EESI, 2010, 2012).

8.1.4 The household account

Capital income is the main source of household income for all the categories. However, it should be noted that it is precisely the mixed income from agricultural activities that constitutes a significant part of this capital income for those households engaged in the agricultural sector. Despite the significant presence of women in the agricultural sector, their share of wage income derived from agricultural activities is low. The second highest source of household income in urban areas is from formal non-agricultural labour and irrespective of the household head's gender (15.13% for men and 12.26% for

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[4] Not elsewhere classified

women). This observation is the same for male-headed households in rural areas (14.11%). In contrast, the second most important source of income for rural female-headed households is informal non-agricultural unskilled labour (8.93%).

Table A3: Structure of household income (in %)

	Urban male households	Rural male households	Urban female households	Rural female households
Formal male agricultural labour	0.15	0.72	0.03	0
Formal female agricultural labour	0.08	0.00	0.01	0.00
Informal male agricultural labour	0.01	0.26	0	0.03
Informal female agricultural labour	0.01	0.13	0.01	0.24
Male formal non-agricultural skilled labour	15.13	14.11	1.26	5.21
Female formal non-agricultural skilled labour	4.47	3.79	12.25	4.52
Male formal non-agricultural unskilled labour	2.45	2.44	0.35	0.47
Female formal non-agricultural unskilled labour	0.75	0.37	3.37	0.61
Male informal non-agricultural skilled labour	1.11	0.92	0.16	0.13
Female informal non-agricultural skilled labour	0.51	0.55	1.19	0.85
Male informal non-agricultural unskilled labour	3.15	9.66	0.88	1.13
Female informal non-agricultural unskilled labour	1.55	4.49	4.48	8.93
Capital income	59	45.49	57.77	60.47
Urban male household transfers	0.99	0.59	2.28	0.6
Rural male household transfers	0.19	0.11	0.43	0.11
Urban female household transfers	0.69	0.41	1.6	0.42
Rural female household transfers	0.07	0.04	0.16	0.04
Business transfers	5.62	8.04	6.78	6.58
Government transfers	2.04	6.66	2.27	8.4
Transfers from the Rest of the World	2.04	1.22	4.72	1.25
Total	100	100	100	100

Source: 2018 SAM - Cameroon

Regardless of the category of household and area of residence, final consumption (FC) is primarily made up of agri-food products, manufactured goods, agricultural products and market services. As regards agri-food products, they appear more frequently in the consumption baskets of rural households, regardless of the household head's gender (26.95% and 22.47% for rural male and female households respectively, compared to 22.11% and 19.65% for urban households). The same trend can be observed for manufactured goods, which represent 18.04% and 19.13% of the final consumption of rural male and female households, compared to 17.05% and 6.64% for urban male and female households. This trend can be explained by the fact that in urban areas, catering services are widespread and households have become accustomed to using them. This is effectively what can be observed with regard to market services, as they are more heavily consumed by urban households, regardless of the household head's gender (see table below). In rural areas, agricultural products account for more than a fifth of the final consumption of rural women's households (23.49%), while for other households they account for between 12 and 16% (12.53%, 14.76%, 16.08%). It can be seen that whatever the category of household, at least 40% of their final consumption is directly or indirectly linked to agricultural production. We note that for all household categories, at least 40% of their final consumption is directly or indirectly linked to agricultural production.

Table A4: Structure of final consumption of households

Products	Share of FC of urban male households (%)	Share of FC of rural male households (%)	Share of FC of urban female households (%)	Share of FC of rural female households (%)
Corn	1.47	1.91	1.83	3.31
Millet and sorghum	0.70	2.71	0.94	2.14
Paddy rice	0.08	0.20	0.18	0.28
Other cereals	0.01	0.02	0.04	0.06
Tubers	1.19	2.11	2.93	4.23
Bananas	0.47	0.61	0.62	0.58
Oilseeds	1.33	1.70	1.88	2.04
Cotton	0.00	0.00	0.00	0.00
Fruit	0.56	0.65	0.65	0.87
Vegetables	4.40	2.39	4.22	6.96
Cocoa	0.00	0.01	0.00	0.02
Coffee and tea	0.00	0.00	0.00	0.00
Other agricultural products	0.13	0.16	0.16	0.17
Livestock and hunting products	2.16	2.30	2.64	2.84
Forestry and logging products	4.36	5.98	5.10	7.58
Fish and aquaculture products	2.78	1.51	2.04	2.63
Mining and quarrying	0.19	0.20	0.66	0.16
Food and beverage industry	22.11	26.95	19.61	22.47
Nitrogen products and fertilisers	0.06	0.18	0.03	0.19
Manufacturing industries	17.05	18.01	6.64	19.13
Other industries	2.21	2.49	3.13	1.92
Construction	0.05	0.06	0.05	0.04
Transport. storage and communication	10.42	12.17	9.25	0.00
Market services	12.36	11.10	16.35	8.70
Education	3.53	2.27	5.60	0.36
Health and social work	2.55	0.72	0.85	0.27
Other services n.e.c.	9.80	3.60	14.63	13.06
Total	100.00	100.00	100.00	100.00

Source: 2018 SAM – Cameroon

Table A5: Structure of production factors detailed by branch of activity

Branch of activity	Capital	Formal male agricultural labour	Formal female agricultural labour	Informal male agricultural labour	Informal female agricultural labour	Male formal non-agricultural skilled labour	Female formal non-agricultural skilled labour	Male formal non-agricultural unskilled labour	Female formal non-agricultural unskilled labour	Male informal non-agricultural skilled labour	Female informal non-agricultural skilled labour	Male informal non-agricultural unskilled labour	Female informal non-agricultural unskilled labour	Total
Corn	99.7	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Millet and sorghum	99.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Paddy rice	99.5	0.1	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Other cereals	99.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Tubers	90.1	2.8	2.3	2.5	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Bananas	81.6	16.5	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Oilseeds	97.4	0.8	0.5	0.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Cotton	71.8	25.7	1.0	0.9	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Fruit	99.7	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Vegetables	98.6	0.2	0.5	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Cocoa	93.5	4.7	0.2	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Coffee and tea	98.7	0.0	0.0	1.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Other agricultural products	99.4	0.2	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Livestock and hunting products	87.3	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.7	0.5	6.3	4.8	100.0
Forestry and logging products	90.2	0.0	0.0	0.0	0.0	3.9	1.5	0.5	0.2	0.6	0.1	2.6	0.4	100.0
Fish and aquaculture products	99.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2	100.0
Mining and quarrying	89.4	0.0	0.0	0.0	0.0	6.0	2.2	1.6	0.6	0.0	0.0	0.1	0.1	100.0
Food and beverage industry	75.5	0.0	0.0	0.0	0.0	7.2	3.6	2.7	1.3	0.5	0.3	5.2	3.7	100.0
Manufacturing industries	86.7	0.0	0.0	0.0	0.0	4.1	1.5	0.9	0.3	0.6	0.5	2.8	2.5	100.0
Other industries	15.6	0.0	0.0	0.0	0.0	40.5	25.6	5.3	3.3	2.0	1.7	3.2	2.8	100.0
Construction	67.8	0.0	0.0	0.0	0.0	9.2	3.8	1.6	0.7	2.9	1.5	8.3	4.3	100.0
Wholesale and retail trade and repair and maintenance of vehicles	68.9	0.0	0.0	0.0	0.0	4.5	3.4	4.2	3.1	0.7	0.7	7.6	6.9	100.0
Transport, storage and communication	85.2	0.0	0.0	0.0	0.0	6.7	3.8	0.6	0.4	0.5	0.4	1.3	1.1	100.0
Market services	72.3	0.0	0.0	0.0	0.0	10.7	6.8	0.8	0.5	0.5	0.5	3.9	3.9	100.0
Public administration and social security	21.3	0.0	0.0	0.0	0.0	11.8	62.2	0.7	3.9	0.0	0.0	0.0	0.0	100.0
Education	19.9	0.0	0.0	0.0	0.0	40.8	35.1	1.5	1.3	0.6	0.4	0.2	0.2	100.0
Health and social work	3.0	0.0	0.0	0.0	0.0	39.0	36.7	9.0	8.5	0.5	0.6	1.3	1.5	100.0
Other services n.e.c.	71.1	0.0	0.0	0.0	0.0	7.0	5.3	2.4	1.8	1.4	1.4	4.8	4.8	100.0

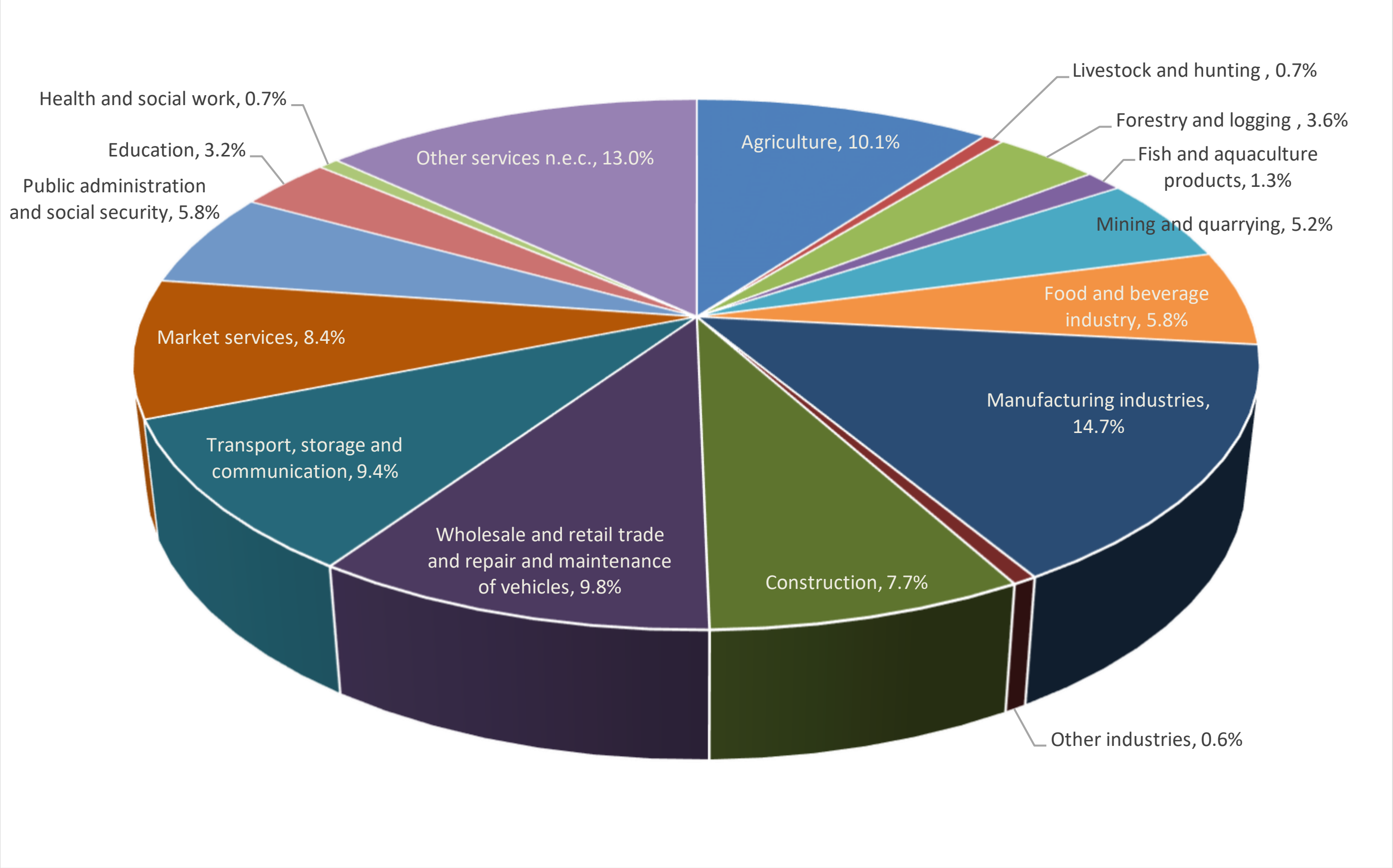
Source: 2018 SAM - Cameroon

Table A6: Structure of labour in the agricultural branches

Branch of activity	Corn	Millet and Sorghum	Paddy rice	Other cereals	Tubers	Bananas	Oil seeds	Cotton	Fruit	Vegetables	Cocoa	Coffee and tea	Other agricultural products
Capital	21.2	25.8	25.0	28.6	28.3	89.4	31.0	91.1	30.9	17.1	71.4	0.8	30.2
Formal male agricultural labour	21.2	12.7	13.4	28.6	23.4	10.3	20.7	3.7	20.7	34.2	2.7	0.3	21.4
Formal female agricultural labour	26.4	33.0	31.5	28.6	25.8	0.2	32.2	3.2	25.7	24.9	12.9	81.9	37.2
Informal male agricultural labour	31.3	28.4	30.1	14.3	22.5	0.1	16.1	2.1	22.7	23.8	12.9	17.0	11.2
Informal female agricultural labour	21.2	25.8	25.0	28.6	28.3	89.4	31.0	91.1	30.9	17.1	71.4	0.8	30.2
Total	100	100	100	100	100	100	100	100	100	100	100	100	100

Source: 2018 SAM - Cameroon

Graph A2: Breakdown of GDP by branch of activity



Source: 2018 SAM - Cameroon

8.2 Estimation of econometric models

Estimates are made for the 13 agricultural products highlighted in our SAM, namely corn, millet and sorghum, tubers, oilseeds, other cereals, rice, coffee and tea, cocoa, vegetables, cotton, fruit, bananas and other agricultural products.

Owing to the availability of data, the estimates cover the period 1961-2018.

The data on climate change indicators is taken from the Climate change knowledge portal. This data source also provided us with the variables for each region, which allowed us to calculate them for each AEZ. The production index data for each product is provided by FAOStat, and the input data is provided by the World Development Indicators. The above-mentioned sources allowed us to obtain data per product only for the production index variable. All other variables were aggregated at the agricultural level. We therefore made some assumptions in order to disaggregate certain variables according to the products of interest in our study. Regarding labour, we have applied the labour structure by agricultural branch of the SAM to the data set. With regard to land and fertilisers, we applied the capital structure by agricultural branches of the SAM to the data set. Rainfall, temperature and capital were left unchanged.

8.2.1 The econometric methodology

The model specified by equation (5) is estimated by the Autoregressive Distributed Lag (ARDL) method, proposed by Pesaran et al. (2001). Compared to other conventional co-integration methods (Engle and Granger, 1987 and Johansen, 1991), the ARDL method has two main advantages. Firstly, it can be applied to any degree of integration of the variables used: purely I(0), purely I(1) or mixed. Secondly, it offers the possibility of dealing simultaneously with long-term dynamics and short-term adjustments. We therefore adopt this method to analyse the dynamic relationship between climate change (and other inputs) and agricultural production of each good.

The implementation of the ARDL method requires that unit root tests be performed for the variables beforehand. Therefore, to study the stationarity of the variables in their degree of integration, we perform the augmented Dickey-Fuller test (ADF). Subsequently, the number of lags of the dependent and explanatory variables is selected using the Akaike information criterion (AIC). Therefore, the model is analysed using the ARDL procedure, because of the need to take stock of the long-term and short-term consequences of our analysis. ARDL modelling with the appropriate lags will allow the correction of correlation and endogeneity problems of the series.

8.2.2 Analysis of the econometric modelling results

The results of the descriptive statistics for all the variables are presented in Table A9. We find that during the period 1961 and 2018, the average temperature in Cameroon varied between 24.06°C and 25.27°C and the average rainfall varied between 1323.78 and 1859.01mm. Furthermore, analysis of these statistics also shows that, on average over the period considered, the products with the highest agricultural productivity indices are coffee and tea, millet and sorghum, and cocoa, with values estimated to be 4.84, 4.05 and 3.92 respectively.

The graph A24 presents the comparative evolution of the climatic variables and the production index of each product over the period 1961-2018. Three main findings emerged. Firstly, on average and with the exception of tea and coffee, production of all the products examined has increased over the last six decades. Secondly, during this period, the flow of precipitation has followed a relatively constant trend, while the temperature has shown an increasing trend. Thirdly, the increase in temperature has usually been accompanied with an increase in the productivity of these products, although this has not always been the case for rainfall.

With regard to the econometric results more specifically, the application of ADF unit root tests on the series studied, leads to the rejection of the stationarity hypothesis for all the series, except for the production index series for corn, millet and sorghum, coffee and tea, tubers, cotton and vegetables; labour for all these products; land for oilseeds and vegetables; and fertilisers for cocoa, oilseeds, corn and other cereals, which are stationary in level. The results also show that the other series are integrated of order I(1). No series is therefore integrated of order two I(2) or higher, which is crucial for the application of the ARDL method.

For the choice of the number of lags, the AIC information criterion for each model estimated was applied. These tables also present the short-term and medium-term dynamics of the climatic variables as well as the other inputs, on the productivity of each product. To estimate the model in equation (5), we introduce in turn temperature (temp) and precipitation (pluv).

Concentrating exclusively on the short-term results (second section of the results tables), we find: (i) a negative impact of rainfall on the production of cotton; (ii) a negative impact of temperature on the production of corn; (iii) a positive impact of rainfall on the production of cocoa; (iv) a positive impact of temperature on the production of rice; (v) a negative impact of temperature and a positive impact of rainfall on tuber production; (vi) a negative impact of temperature on the production of cereals; (vii) a positive impact of rainfall on the production of fruit; and (viii) a negative impact of rainfall on the yields of other products. With regard to the other crops (vegetables, coffee, bananas, millet, oilseeds), we find no significant impacts.

The coefficients of the model are used to calculate the productivity elasticities of each product in relation to the climatic variables. The variation in the yields of each product as a result of climate shocks is thus obtained as the product of the elasticities calculated for each type of climate shock. The climate change coefficients are obtained for the optimistic and pessimistic climate change scenarios. Indeed, Cameroon's Climate-Resilient Investment Plan (2020) projects minimum (optimistic) and maximum (pessimistic) temperature and rainfall variations differing by AEZ by 2040-2060. As regards temperatures, the AEZ with the lowest variation is the moist savannah zone (1.2%) and the one with the highest increase is the Sudano-Sahelian zone (3%). With regard to rainfall, under the optimistic scenario, rainfall is expected to decline by 10% on average, while under the pessimistic scenario it is expected to decline by 20% on average across the country.

Table A7: Variation in temperature by AEZ and precipitation

Temperature	**Optimistic** *(in °C)*	**Pessimistic** *(in °C)*
SSZ	1.25	3.00
HSZ-BFZ	1.55	2.75
MSZ	1.20	2.00
MZ	1.30	2.50
Precipitation	**Optimistic** *(in %)*	**Pessimistic** *(in %)*
National	-10	-20

Source: Cameroon's climate-resilient investment plan

These variations allow us to calculate the climate change coefficients for the optimistic and pessimistic scenarios. As the temperatures are given as absolute variations, the associated percentage is obtained by adding the above change values to the average temperature values calculated over the period 1961-2018 for the AEZ. The following table shows the relative temperature changes.

Table A8: Percentage change in temperature by AEZ

Temperature	**Optimistic** *(in °C)*	**Pessimistic** *(in °C)*
SSZ	4.8	11.4
HSZ-BFZ	6.4	11.3
MSZ	5.3	8.8
MZ	5.1	9.9

Source: Authors' calculations

Table A9: Results of the stationarity test and descriptive statistics

Variables	Order of stationarity	Descriptive statistics				
		N	Mean	Standard deviation	Min	Max
Temp	I(0)	58	24.692	0.285	24.060	25.270
Pluvio	I(0)	58	1599.252	91.289	1323.780	1859.010
Temp2	I(0)	58	609.770	14.056	578.884	638.573
Pluvio2	I(0)	58	2565798.000	292055.100	1752394.000	3455918.000
Temp_Pluvio	I(1)	58	39485.370	2246.405	32684.130	46326.530
Ind_prod_Mais	I(0)	58	3.441	0.614	2.708	4.687
Ind_prod_Mil_Sorgho	I(0)	58	4.057	0.327	2.890	4.642
Ind_prod_Rizpaddy	I(1)	58	2.893	0.975	0.307	4.915
Ind_prod_Oleagineux	I(1)	58	3.540	0.556	2.595	4.703
Ind_prod_Cacao	I(1)	58	3.926	0.372	3.347	4.765
Ind_prod_Cafe_The	I(0)	58	4.844	0.277	4.128	5.345
Ind_prod_Bananes	I(1)	58	3.674	0.650	2.514	4.714
Ind_prod_autres_Cereales	I(1)	58	3.524	0.555	2.879	4.678
Ind_prod_Tubercules	I(0)	58	3.612	0.535	2.933	4.659
Ind_prod_Fruits	I(1)	58	3.576	0.587	2.755	4.675
Ind_prod_Coton_graine	I(0)	58	3.654	0.703	2.151	4.705
Ind_prod__total	I(1)	58	3.652	0.529	2.770	4.642
Ind_prod__légumes	I(0)	58	3.527	0.633	2.500	4.700
Log_lab_Mais	I(0)	58	9.726	1.338	6.365	10.738
Log_lab_Mil_sorgho	I(0)	58	9.046	1.338	5.685	10.058
Log_lab_riz	I(0)	58	8.698	1.338	5.337	9.710
Log_lab_autres_cereales	I(0)	58	12.284	1.338	8.924	13.297
Log_lab_tubercules	I(0)	58	11.485	1.338	8.125	12.498
Log_lab_banane	I(0)	58	12.891	1.338	9.531	13.904
Log_lab_oleagineux	I(0)	58	13.188	1.338	9.828	14.201
Log_lab_coton	I(0)	58	5.268	1.338	1.908	6.281
Log_lab_fruits	I(0)	58	11.457	1.338	8.096	12.469
Log_lab_legumes	I(0)	58	12.141	1.338	8.780	13.153
Log_lab_cacao	I(0)	58	12.591	1.338	9.230	13.603
Log_lab_cafe_the	I(0)	58	9.106	1.338	5.746	10.119
Log_lab_autres	I(0)	58	9.984	1.338	6.624	10.997
Log_Terre_Mais	I(1)	58	9.397	0.078	9.235	9.496
Log_Terre_Mil_sorgho	I(1)	58	9.851	0.078	9.689	9.950
Log_Terre_riz	I(1)	58	7.597	0.078	7.436	7.697
Log_Terre_autres_cereales	I(1)	58	7.962	0.078	7.800	8.061
Log_Terre_tubercules	I(1)	58	9.000	0.078	8.838	9.099
Log_Terre_banane	I(1)	58	8.477	0.078	8.316	8.577
Log_Terre_oleagineux	I(0)	58	7.687	0.078	7.525	7.786
Log_Terre_Coton	I(1)	58	7.968	0.078	7.807	8.068
Log_Terre_fruits	I(1)	58	4.520	0.078	4.358	4.619
Log_Terre_legumes	I(0)	58	9.783	0.078	9.621	9.882
Log_Terre_cacao	I(1)	58	9.163	0.078	9.002	9.263
Log_Terre_cafe_the	I(1)	58	8.013	0.078	7.851	8.112
Log_Terre_autres	I(1)	58	8.862	0.078	8.700	8.961
Log_Fertilisants_Mais	I(0)	58	10.965	0.826	8.802	12.108
Log_Fertilisants_Mil_sorgho	I(1)	58	11.419	0.826	9.256	12.562
Log_Fertilisants_riz	I(1)	58	9.165	0.826	7.003	10.309
Log_Fertilisants_autres_cereale	I(0)	58	9.530	0.826	7.367	10.674
Log_Fertilisants_tubercules	I(1)	58	10.568	0.826	8.406	11.712
Log_Fertilisants_banane	I(1)	58	10.045	0.826	7.883	11.189
Log_Fertilisants_oleagineux	I(0)	58	9.255	0.826	7.092	10.398
Log_Fertilisants_Coton	I(1)	58	9.536	0.826	7.374	10.680
Log_Fertilisants_fruits	I(1)	58	6.088	0.826	3.925	7.232
Log_Fertilisants_legumes	I(1)	58	11.351	0.826	9.189	12.495
Log_Fertilisants_cacao	I(0)	58	10.731	0.826	8.569	11.875
Log_Fertilisants_cafe_the	I(1)	58	9.581	0.826	7.418	10.724
Log_Fertilisants_autres	I(1)	58	10.430	0.826	8.267	11.574
Livestock_production_index	I(1)	58	4.006	0.512	3.094	4.736
log_capital	I(1)	58	7.037	0.988	5.324	8.548

Source: The authors.

Note: *Descriptive statistics are calculated after logarithmic transformation of the variables.*

Table A10: Effect of climate change on cotton production

	(1)	(2)	(3)	(4)	(5)	(6)	a7	a8
ADJ								
L.Ind_prod_Coton_graine	-0.434***	-0.462***	-0.483***	-0.393**	-0.454**	-0.475***	-0.395**	-0.226
	(0.138)	(0.150)	(0.151)	(0.154)	(0.171)	(0.161)	(0.180)	(0.184)
LR								
Log_lab_coton	-0.278	-0.207	-0.271*	-0.575**	-0.352	-0.343	-0.408	-0.425
	(0.251)	(0.238)	(0.147)	(0.279)	(0.264)	(0.247)	(0.343)	(0.563)
Log_Terre_Coton	4.978	3.322	7.929*	7.163	8.358	7.557	2.705	11.934
	(4.076)	(4.145)	(4.578)	(5.243)	(5.590)	(4.843)	(6.622)	(14.618)
Log_Fertilisants_Coton	0.270	0.279	0.244	0.707*	0.323	0.343	0.593	0.052
	(0.339)	(0.320)	(0.233)	(0.392)	(0.343)	(0.320)	(0.457)	(0.812)
log_Capital	0.466	0.542	0.303	0.094	0.383	0.413	-0.024	-0.672
	(0.358)	(0.356)	(0.197)	(0.270)	(0.349)	(0.322)	(0.496)	(1.212)
temp	-0.181	76.392			2.050	-0.368	84.511	132.091
	(0.917)	(66.452)			(6.546)	(0.879)	(79.344)	(144.363)
temp2		-1.553					-1.697	-1.935
		(1.351)					(1.606)	(2.647)
pluvio			0.002	0.131	0.040	0.002	0.169	0.756
			(0.003)	(0.086)	(0.100)	(0.003)	(0.113)	(0.752)
pluvio2				-0.000			-0.000	-0.000
				(0.000)			(0.000)	(0.000)
temp_pluvio					-0.001			-0.022
					(0.004)			(0.024)
SR								
D.Log_lab_coton	-0.147	-0.166	-0.265	-0.337	-0.263	-0.261	-0.396	-0.361
	(0.255)	(0.257)	(0.251)	(0.240)	(0.271)	(0.268)	(0.266)	(0.247)
LD.Log_lab_coton	0.473*	0.431	0.576**	0.680***	0.601**	0.592**	0.608**	0.645**
	(0.258)	(0.261)	(0.242)	(0.234)	(0.265)	(0.260)	(0.269)	(0.250)
D.Log_Terre_Coton	-6.805	-6.594	-4.485	-4.247	-4.807	-4.675	-4.376	-6.875
	(4.465)	(5.043)	(4.364)	(4.075)	(4.677)	(4.602)	(4.977)	(4.757)
LD.Log_Terre_Coton	-2.963	-0.328	-5.102	-5.484	-4.453	-5.078	-2.178	3.736
	(4.570)	(4.917)	(4.436)	(4.296)	(4.973)	(4.646)	(5.050)	(5.417)
L2D.Log_Terre_Coton	-2.830	-2.674	-4.849	-5.555	-5.515	-5.376	-4.175	-3.866
	(4.529)	(4.926)	(4.462)	(4.228)	(4.865)	(4.787)	(5.033)	(4.671)
D.Log_Fertilisants_Coton	0.271*	0.349**	0.296*	0.179	0.278	0.279	0.297	0.288
	(0.158)	(0.166)	(0.152)	(0.154)	(0.189)	(0.186)	(0.191)	(0.178)
D.log_Capital	-0.242	-0.394	-0.199	-0.160	-0.276	-0.380	-0.442	0.446
	(0.643)	(0.652)	(0.612)	(0.571)	(0.720)	(0.659)	(0.646)	(0.725)
D.temp	0.179	-20.097			0.209	0.211	-16.428	-3.079
	(0.304)	(27.178)			(0.322)	(0.318)	(25.573)	(24.503)
LD.temp	0.134	-31.633			0.151	0.160	-19.847	-14.671
	(0.226)	(23.731)			(0.234)	(0.229)	(22.860)	(21.339)
L2D.temp	0.053	-4.409			-0.009	-0.007	-4.459	1.072
	(0.159)	(19.016)			(0.172)	(0.169)	(18.441)	(17.294)
D.temp2		0.411					0.331	0.060
		(0.552)					(0.519)	(0.497)
LD.temp2		0.644					0.403	0.297
		(0.482)					(0.464)	(0.433)
L2D.temp2		0.090					0.088	-0.023
		(0.386)					(0.374)	(0.351)
D.pluvio			-0.001	-0.051**	-0.001	-0.001	-0.061**	-0.052**
			(0.001)	(0.020)	(0.001)	(0.001)	(0.024)	(0.022)
LD.pluvio			0.000	-0.040**	-0.000	-0.000	-0.046**	-0.039**
			(0.001)	(0.016)	(0.001)	(0.001)	(0.019)	(0.018)
L2D.pluvio			-0.000	-0.020*	-0.000	-0.000	-0.029*	-0.022
			(0.001)	(0.012)	(0.001)	(0.001)	(0.015)	(0.014)
L3D.pluvio			0.000	-0.013*	0.000	0.000	-0.020**	-0.024**
			(0.000)	(0.007)	(0.000)	(0.000)	(0.009)	(0.009)
D.pluvio2				0.000**			0.000**	0.000**
				(0.000)			(0.000)	(0.000)
LD.pluvio2				0.000**			0.000**	0.000**
				(0.000)			(0.000)	(0.000)
L2D.pluvio2				0.000*			0.000*	0.000
				(0.000)			(0.000)	(0.000)
L3D.pluvio2				0.000*			0.000**	0.000**
				(0.000)			(0.000)	(0.000)
Constant	-15.557	-446.704	-31.797	-63.365**	-55.306	-26.440	-475.623	-528.688
	(18.168)	(393.426)	(20.073)	(24.563)	(77.186)	(22.457)	(392.582)	(364.988)
Observations	55	55	54	54	54	54	54	54
R-squared	0.417	0.477	0.509	0.638	0.536	0.534	0.699	0.752

Table A11: Effect of climate change on corn production

	(1)	(2)	(3)	(4)	(5)	(6)	a7	a8
ADJ								
L.Ind_prod_Mais	-0.231**	-0.207*	-0.242***	-0.228**	-0.222**	-0.229**	-0.141	-0.101
	(0.087)	(0.121)	(0.087)	(0.092)	(0.093)	(0.093)	(0.152)	(0.153)
LR								
Log_lab_Mais	0.030	0.061	0.038	-0.118	0.098	0.091	0.220	0.196
	(0.264)	(0.323)	(0.183)	(0.251)	(0.332)	(0.322)	(0.766)	(1.028)
Log_Terre_Mais	-9.637**	-10.637	-10.374*	-11.594*	-13.331*	-10.787	-17.863	-33.145
	(4.449)	(6.477)	(5.800)	(6.467)	(7.540)	(6.555)	(22.550)	(54.022)
Log_Fertilisants_Mais	-0.050	-0.063	0.010	0.358	-0.030	-0.105	-0.054	0.560
	(0.375)	(0.426)	(0.286)	(0.418)	(0.442)	(0.432)	(0.810)	(1.300)
log_Capital	1.343***	1.475**	1.308***	1.181***	1.427***	1.299***	1.494	1.992
	(0.394)	(0.566)	(0.262)	(0.293)	(0.464)	(0.421)	(1.024)	(2.021)
temp	-0.045	76.237			-7.836	0.190	147.288	243.028
	(0.936)	(145.099)			(8.449)	(1.121)	(344.682)	(614.230)
temp2		-1.551					-2.979	-5.534
		(2.947)					(6.972)	(13.396)
pluvio			-0.000	0.083	-0.124	-0.001	0.078	-0.268
			(0.003)	(0.076)	(0.129)	(0.004)	(0.161)	(0.547)
pluvio2				-0.000			-0.000	-0.000
				(0.000)			(0.000)	(0.000)
temp_pluvio					0.005			0.019
					(0.005)			(0.034)
SR								
D.Log_lab_Mais	-0.062	-0.081	-0.112	-0.099	-0.109	-0.106	-0.081	-0.101
	(0.146)	(0.147)	(0.154)	(0.163)	(0.166)	(0.166)	(0.170)	(0.167)
LD.Log_lab_Mais	0.154	0.143	0.174	0.206	0.148	0.160	0.158	0.150
	(0.148)	(0.150)	(0.149)	(0.159)	(0.162)	(0.162)	(0.173)	(0.170)
D.Log_Terre_Mais	-0.663	-0.734	-1.014	-1.535	-0.819	-1.300	-3.196	-1.783
	(2.530)	(2.742)	(2.635)	(2.723)	(2.832)	(2.802)	(3.061)	(3.187)
LD.Log_Terre_Mais	0.866	2.625	1.104	0.472	0.507	1.228	3.296	1.653
	(2.561)	(2.766)	(2.592)	(2.738)	(2.848)	(2.772)	(3.110)	(3.292)
L2D.Log_Terre_Mais	2.599	3.166	2.230	1.567	3.169	2.713	3.460	3.570
	(2.630)	(2.876)	(2.654)	(2.798)	(2.950)	(2.925)	(3.189)	(3.136)
D.Log_Fertilisants_Mais	-0.071	-0.040	-0.005	-0.033	-0.002	-0.015	0.027	0.056
	(0.090)	(0.095)	(0.089)	(0.101)	(0.113)	(0.113)	(0.123)	(0.123)
D.log_Capital	-0.350	-0.335	-0.530	-0.525	-0.618	-0.461	-0.338	-0.637
	(0.393)	(0.399)	(0.392)	(0.403)	(0.457)	(0.434)	(0.432)	(0.480)
D.temp	0.032	-20.013			-0.004	-0.009	-23.370	-30.545
	(0.170)	(18.385)			(0.198)	(0.199)	(20.997)	(21.318)
LD.temp	0.025	-23.323			0.030	0.016	-27.913	-30.853*
	(0.129)	(14.730)			(0.144)	(0.144)	(16.911)	(16.766)
L2D.temp	0.083	-8.591			0.064	0.064	-7.483	-8.911
	(0.092)	(10.727)			(0.105)	(0.106)	(11.994)	(11.837)
D.temp2		0.407					0.473	0.619
		(0.373)					(0.426)	(0.432)
LD.temp2		0.473					0.567	0.627*
		(0.299)					(0.343)	(0.340)
L2D.temp2		0.176					0.154	0.183
		(0.218)					(0.243)	(0.240)
D.pluvio			-0.000	-0.018	0.000	0.000	-0.013	-0.018
			(0.001)	(0.013)	(0.001)	(0.001)	(0.015)	(0.015)
LD.pluvio			0.000	-0.011	0.000	0.000	-0.004	-0.007
			(0.001)	(0.011)	(0.001)	(0.001)	(0.012)	(0.012)
L2D.pluvio			0.000	-0.004	0.000	0.000	0.004	0.001
			(0.000)	(0.008)	(0.000)	(0.000)	(0.010)	(0.010)
L3D.pluvio			0.000	-0.001	0.000	0.000	0.002	0.003
			(0.000)	(0.005)	(0.000)	(0.000)	(0.006)	(0.006)
D.pluvio2				0.000			0.000	0.000
				(0.000)			(0.000)	(0.000)
LD.pluvio2				0.000			0.000	0.000
				(0.000)			(0.000)	(0.000)
L2D.pluvio2				0.000			-0.000	-0.000
				(0.000)			(0.000)	(0.000)
L3D.pluvio2				0.000			-0.000	-0.000
				(0.000)			(0.000)	(0.000)
Constant	19.840	-174.834	22.306	8.493	69.853	21.195	-243.212	-250.609
	(12.545)	(286.382)	(13.725)	(18.327)	(48.134)	(15.383)	(363.928)	(357.760)
Observations	55	55	54	54	54	54	54	54
R-squared	0.312	0.385	0.330	0.402	0.369	0.345	0.558	0.591

Table A12: Effect of climate change on the production of vegetables

	(1)	(2)	(3)	(4)	(5)	(6)	a7	a8
ADJ								
L.Ind_prod_Legumes	-0.173*	-0.232*	-0.158*	-0.115	-0.158	-0.158	-0.227	-0.234
	(0.095)	(0.117)	(0.085)	(0.084)	(0.094)	(0.094)	(0.144)	(0.146)
LR								
Log_lab_legumes	-0.045	-0.090	0.009	-0.282	-0.073	-0.074	-0.374	-0.417
	(0.368)	(0.287)	(0.266)	(0.392)	(0.440)	(0.437)	(0.284)	(0.283)
Log_Terre_legumes	-9.913	-7.591	-8.262	-6.483	-4.643	-7.509	-2.841	-4.205
	(6.292)	(5.197)	(8.467)	(9.555)	(9.202)	(8.814)	(6.438)	(6.891)
Log_Fertilisants_legumes	-0.142	-0.026	-0.399	-0.140	-0.383	-0.279	0.270	0.411
	(0.578)	(0.429)	(0.526)	(0.782)	(0.751)	(0.700)	(0.458)	(0.462)
log_Capital	1.575**	1.316***	1.397***	1.209**	1.298**	1.443**	0.838*	0.881*
	(0.582)	(0.466)	(0.436)	(0.533)	(0.600)	(0.594)	(0.426)	(0.427)
temp	-0.654	-79.713			9.356	-0.299	-100.297	-105.216
	(1.305)	(82.620)			(12.001)	(1.558)	(77.052)	(75.028)
temp2		1.607					2.033	2.023
		(1.679)					(1.559)	(1.531)
pluvio			-0.000	0.154	0.148	0.000	0.125	0.055
			(0.005)	(0.122)	(0.179)	(0.005)	(0.077)	(0.123)
pluvio2				-0.000			-0.000	-0.000
				(0.000)			(0.000)	(0.000)
temp_pluvio					-0.006			0.003
					(0.007)			(0.005)
SR								
D.Log_lab_legumes	0.293*	0.310*	0.196	0.233*	0.188	0.184	0.232	0.223
	(0.152)	(0.157)	(0.148)	(0.128)	(0.159)	(0.159)	(0.143)	(0.145)
LD.Log_lab_legumes	-0.283*	-0.264	-0.256*	-0.248*	-0.227	-0.236	-0.183	-0.179
	(0.159)	(0.169)	(0.145)	(0.129)	(0.159)	(0.159)	(0.166)	(0.168)
D.Log_Terre_legumes	-0.504	-1.833	-2.094	-2.457	-2.363	-1.900	-3.646	-2.974
	(2.635)	(2.971)	(2.532)	(2.155)	(2.734)	(2.686)	(2.602)	(2.834)
LD.Log_Terre_legumes	2.310	2.281	3.185	2.554	3.419	2.834	2.510	1.753
	(2.678)	(2.976)	(2.496)	(2.136)	(2.724)	(2.649)	(2.718)	(2.993)
L2D.Log_Terre_legumes	-0.420	-0.040	-0.703	-2.162	-1.540	-1.113	-2.285	-2.240
	(2.760)	(3.061)	(2.564)	(2.187)	(2.828)	(2.788)	(2.702)	(2.738)
D.Log_Fertilisants_legumes	-0.046	-0.022	0.064	0.099	0.049	0.059	0.107	0.113
	(0.094)	(0.102)	(0.085)	(0.081)	(0.109)	(0.109)	(0.114)	(0.116)
D.log_Capital	-0.305	-0.329	-0.254	-0.279	-0.100	-0.243	-0.416	-0.558
	(0.403)	(0.418)	(0.368)	(0.313)	(0.436)	(0.409)	(0.362)	(0.428)
D.temp	0.058	15.693			-0.041	-0.035	16.644	15.900
	(0.182)	(19.017)			(0.199)	(0.199)	(19.596)	(19.883)
LD.temp	-0.009	2.010			-0.049	-0.036	2.880	3.199
	(0.137)	(15.984)			(0.143)	(0.142)	(16.244)	(16.461)
L2D.temp	0.035	-0.085			-0.025	-0.025	1.309	1.418
	(0.096)	(11.846)			(0.101)	(0.101)	(11.166)	(11.312)
D.temp2		-0.317					-0.337	-0.322
		(0.386)					(0.397)	(0.403)
LD.temp2		-0.041					-0.058	-0.064
		(0.324)					(0.329)	(0.333)
L2D.temp2		0.002					-0.027	-0.030
		(0.240)					(0.226)	(0.229)
D.pluvio			-0.001	-0.006	-0.001	-0.001	-0.015	-0.017
			(0.001)	(0.012)	(0.001)	(0.001)	(0.015)	(0.016)
LD.pluvio			-0.000	0.004	-0.000	-0.000	-0.002	-0.004
			(0.001)	(0.010)	(0.001)	(0.001)	(0.013)	(0.013)
L2D.pluvio			-0.000	0.002	-0.000	-0.000	-0.001	-0.003
			(0.000)	(0.007)	(0.000)	(0.000)	(0.009)	(0.009)
L3D.pluvio			-0.000	0.002	-0.000	-0.000	0.000	0.001
			(0.000)	(0.004)	(0.000)	(0.000)	(0.005)	(0.005)
D.pluvio2				0.000			0.000	0.000
				(0.000)			(0.000)	(0.000)
LD.pluvio2				-0.000			0.000	0.000
				(0.000)			(0.000)	(0.000)
L2D.pluvio2				-0.000			0.000	0.000
				(0.000)			(0.000)	(0.000)
L3D.pluvio2				-0.000			-0.000	-0.000
				(0.000)			(0.000)	(0.000)
Constant	18.633	245.377	12.560	-6.581	-29.670	12.348	264.048	303.460
	(13.978)	(278.709)	(13.305)	(14.142)	(46.820)	(15.211)	(310.311)	(320.205)
Observations	55	55	54	54	54	54	54	54
R-squared	0.338	0.375	0.459	0.674	0.490	0.475	0.725	0.730

Table A13: Effect of climate change on the production of coffee

	(1)	(2)	(3)	(4)	(5)	(6)	a7	a8
ADJ								
L.Ind_prod_Cafe_The	-0.721***	-0.723**	-0.807***	-0.711**	-0.769**	-0.764**	-0.568*	-0.564
	(0.265)	(0.285)	(0.262)	(0.263)	(0.299)	(0.292)	(0.313)	(0.328)
LR								
Log_lab_cafe_the	0.238*	0.225*	0.209**	0.224**	0.298**	0.297**	0.285	0.288
	(0.122)	(0.132)	(0.078)	(0.107)	(0.127)	(0.125)	(0.179)	(0.187)
Log_Terre_cafe_the	0.582	1.005	-0.862	-0.184	-1.666	-1.587	-2.125	-2.064
	(2.096)	(2.231)	(2.736)	(2.826)	(3.236)	(3.118)	(4.682)	(4.900)
Log_Fertilisants_cafe_the	0.023	0.017	0.071	0.008	-0.064	-0.067	-0.106	-0.115
	(0.166)	(0.173)	(0.127)	(0.172)	(0.171)	(0.167)	(0.247)	(0.291)
log_Capital	-0.458**	-0.475**	-0.355***	-0.347**	-0.434**	-0.438**	-0.426	-0.427
	(0.181)	(0.195)	(0.113)	(0.132)	(0.189)	(0.183)	(0.286)	(0.296)
temp	0.185	-9.832			0.074	0.443	12.589	12.827
	(0.427)	(36.468)			(3.060)	(0.445)	(46.202)	(47.815)
temp2		0.203					-0.245	-0.242
		(0.741)					(0.936)	(0.966)
pluvio			-0.001	-0.006	-0.008	-0.002	0.017	0.021
			(0.001)	(0.029)	(0.046)	(0.002)	(0.044)	(0.086)
pluvio2				0.000			-0.000	-0.000
				(0.000)			(0.000)	(0.000)
temp_pluvio					0.000			-0.000
					(0.002)			(0.004)
SR								
LD.Ind_prod_Cafe_The	-0.307*	-0.308	-0.227	-0.143	-0.273	-0.278	-0.184	-0.187
	(0.181)	(0.193)	(0.178)	(0.181)	(0.204)	(0.196)	(0.210)	(0.221)
D.Log_lab_cafe_the	-0.105	-0.103	-0.036	-0.064	-0.099	-0.099	-0.113	-0.111
	(0.204)	(0.215)	(0.225)	(0.214)	(0.229)	(0.226)	(0.224)	(0.231)
LD.Log_lab_cafe_the	-0.012	0.011	-0.089	0.003	-0.081	-0.077	0.041	0.042
	(0.213)	(0.225)	(0.221)	(0.213)	(0.233)	(0.228)	(0.233)	(0.239)
D.Log_Terre_cafe_the	-6.265*	-5.224	-5.633	-5.884	-6.437	-6.515*	-7.542*	-7.661
	(3.405)	(4.089)	(3.750)	(3.524)	(3.847)	(3.731)	(4.154)	(4.611)
LD.Log_Terre_cafe_the	-4.377	-4.901	-4.795	-3.362	-4.130	-4.050	-0.961	-0.840
	(3.732)	(4.215)	(3.994)	(3.920)	(4.109)	(3.990)	(4.503)	(4.953)
L2D.Log_Terre_cafe_the	6.105	5.176	4.573	4.573	7.621*	7.578*	7.466	7.482
	(3.769)	(4.297)	(3.983)	(3.808)	(4.210)	(4.128)	(4.485)	(4.597)
D.Log_Fertilisants_cafe_the	-0.004	-0.026	-0.007	0.066	0.031	0.029	0.097	0.095
	(0.126)	(0.138)	(0.130)	(0.132)	(0.158)	(0.154)	(0.159)	(0.165)
D.log_Capital	-0.776	-0.775	-0.882	-0.753	-0.840	-0.817	-0.774	-0.752
	(0.519)	(0.553)	(0.564)	(0.541)	(0.608)	(0.567)	(0.575)	(0.681)
D.temp	-0.131	-0.474			-0.254	-0.253	-6.950	-6.659
	(0.259)	(22.266)			(0.300)	(0.295)	(21.497)	(22.432)
LD.temp	0.084	5.412			0.013	0.013	-1.142	-1.081
	(0.204)	(19.415)			(0.223)	(0.220)	(19.104)	(19.573)
L2D.temp	0.086	7.801			0.087	0.089	-3.244	-3.215
	(0.142)	(15.308)			(0.160)	(0.157)	(15.442)	(15.810)
D.temp2		0.006					0.139	0.133
		(0.452)					(0.436)	(0.455)
LD.temp2		-0.108					0.027	0.026
		(0.394)					(0.387)	(0.397)
L2D.temp2		-0.157					0.067	0.066
		(0.311)					(0.313)	(0.320)
D.pluvio			0.001	0.017	0.002	0.002	0.007	0.008
			(0.001)	(0.018)	(0.001)	(0.001)	(0.020)	(0.022)
LD.pluvio			0.001	0.010	0.001	0.001	0.006	0.006
			(0.001)	(0.015)	(0.001)	(0.001)	(0.018)	(0.018)
L2D.pluvio			0.001	0.009	0.001	0.001	0.005	0.006
			(0.001)	(0.011)	(0.001)	(0.001)	(0.013)	(0.014)
L3D.pluvio			0.000	-0.001	0.000	0.000	-0.007	-0.007
			(0.000)	(0.007)	(0.000)	(0.000)	(0.009)	(0.009)
D.pluvio2				-0.000			-0.000	-0.000
				(0.000)			(0.000)	(0.000)
LD.pluvio2				-0.000			-0.000	-0.000
				(0.000)			(0.000)	(0.000)
L2D.pluvio2				-0.000			-0.000	-0.000
				(0.000)			(0.000)	(0.000)
L3D.pluvio2				0.000			0.000	0.000
				(0.000)			(0.000)	(0.000)
Constant	-2.464	84.430	10.885	8.683	16.018	8.494	-84.617	-88.046
	(16.084)	(314.533)	(16.850)	(21.912)	(65.037)	(19.343)	(322.002)	(333.533)
Observations	55	55	54	54	54	54	54	54
R-squared	0.625	0.633	0.603	0.706	0.666	0.666	0.782	0.782

Table A14: Effect of climate change on cocoa production

	(1)	(2)	(3)	(4)	(5)	(6)	a7	a8
ADJ								
L.Ind_prod_Cacao	-0.270**	-0.168	-0.323***	-0.392***	-0.300**	-0.300**	-0.288**	-0.310**
	(0.105)	(0.113)	(0.110)	(0.106)	(0.119)	(0.117)	(0.128)	(0.125)
LR								
Log_lab_cacao	-0.228	-0.248	-0.099	0.175	-0.124	-0.124	0.132	0.189
	(0.223)	(0.342)	(0.130)	(0.139)	(0.227)	(0.224)	(0.237)	(0.225)
Log_Terre_cacao	-5.461	-9.381	-5.960	-5.559*	-6.885	-6.888	-7.616	-4.694
	(3.808)	(8.242)	(4.099)	(3.105)	(4.809)	(4.460)	(5.611)	(4.973)
Log_Fertilisants_cacao	0.281	0.317	0.258	-0.175	0.219	0.219	-0.221	-0.421
	(0.305)	(0.468)	(0.208)	(0.223)	(0.304)	(0.294)	(0.343)	(0.370)
log_Capital	0.950**	1.296	0.736***	0.916***	0.860**	0.860**	1.352**	1.209***
	(0.391)	(0.845)	(0.187)	(0.168)	(0.361)	(0.343)	(0.510)	(0.428)
temp	-0.552	-8.370			-0.168	-0.180	-12.391	-8.369
	(0.837)	(100.593)			(5.368)	(0.838)	(60.390)	(54.972)
temp2		0.153					0.236	0.345
		(2.048)					(1.225)	(1.098)
pluvio			-0.002	-0.122***	-0.002	-0.002	-0.160**	-0.035
			(0.002)	(0.042)	(0.081)	(0.003)	(0.073)	(0.091)
pluvio2				0.000***			0.000**	0.000**
				(0.000)			(0.000)	(0.000)
temp_pluvio					-0.000			-0.006
					(0.003)			(0.004)
SR								
D.Log_lab_cacao	0.060	0.094	0.054	0.101	0.057	0.057	0.158	0.178
	(0.144)	(0.137)	(0.151)	(0.142)	(0.157)	(0.155)	(0.145)	(0.141)
LD.Log_lab_cacao	0.142	0.117	0.157	0.075	0.148	0.148	0.050	0.057
	(0.146)	(0.141)	(0.147)	(0.139)	(0.155)	(0.152)	(0.150)	(0.146)
D.Log_Terre_cacao	-1.817	-2.669	-2.231	-1.745	-3.069	-3.068	-2.844	-4.159
	(2.485)	(2.680)	(2.587)	(2.374)	(2.692)	(2.616)	(2.705)	(2.775)
LD.Log_Terre_cacao	4.987*	3.427	5.671**	7.297***	5.989**	5.987**	6.004**	7.669**
	(2.490)	(2.577)	(2.492)	(2.358)	(2.670)	(2.554)	(2.642)	(2.799)
L2D.Log_Terre_cacao	1.818	0.750	2.075	4.625*	2.661	2.662	3.370	3.420
	(2.639)	(2.697)	(2.683)	(2.584)	(2.997)	(2.928)	(2.919)	(2.841)
D.Log_Fertilisants_cacao	-0.111	-0.109	-0.024	0.053	-0.055	-0.055	-0.033	-0.054
	(0.090)	(0.091)	(0.089)	(0.088)	(0.107)	(0.105)	(0.102)	(0.100)
D.log_Capital	0.122	0.209	0.113	0.076	0.080	0.080	0.093	0.384
	(0.384)	(0.369)	(0.396)	(0.363)	(0.435)	(0.406)	(0.372)	(0.411)
D.temp	0.215	18.583			0.138	0.138	14.866	18.290
	(0.169)	(14.289)			(0.199)	(0.196)	(13.784)	(13.609)
LD.temp	0.215*	20.461			0.178	0.178	15.791	16.542
	(0.127)	(12.595)			(0.141)	(0.138)	(12.364)	(12.046)
L2D.temp	0.149	6.406			0.121	0.121	8.817	9.568
	(0.091)	(9.969)			(0.101)	(0.100)	(9.926)	(9.676)
D.temp2		-0.372					-0.296	-0.366
		(0.290)					(0.280)	(0.276)
LD.temp2		-0.410					-0.315	-0.331
		(0.256)					(0.251)	(0.244)
L2D.temp2		-0.127					-0.175	-0.189
		(0.202)					(0.201)	(0.196)
D.pluvio			0.000	0.039***	0.000	0.000	0.036**	0.042***
			(0.001)	(0.012)	(0.001)	(0.001)	(0.014)	(0.014)
LD.pluvio			0.000	0.028***	0.000	0.000	0.029**	0.032**
			(0.001)	(0.010)	(0.001)	(0.001)	(0.012)	(0.012)
L2D.pluvio			0.000	0.016**	0.000	0.000	0.016*	0.020**
			(0.000)	(0.007)	(0.000)	(0.000)	(0.009)	(0.009)
L3D.pluvio			-0.000	0.009**	-0.000	-0.000	0.008	0.007
			(0.000)	(0.004)	(0.000)	(0.000)	(0.005)	(0.005)
D.pluvio2				-0.000***			-0.000**	-0.000***
				(0.000)			(0.000)	(0.000)
LD.pluvio2				-0.000***			-0.000**	-0.000**
				(0.000)			(0.000)	(0.000)
L2D.pluvio2				-0.000**			-0.000*	-0.000**
				(0.000)			(0.000)	(0.000)
L3D.pluvio2				-0.000**			-0.000	-0.000
				(0.000)			(0.000)	(0.000)
Constant	16.373	32.611	17.618	56.745***	20.122	20.221	101.528	54.098
	(11.141)	(209.385)	(13.616)	(16.948)	(45.383)	(14.015)	(218.161)	(214.697)
Observations	55	55	54	54	54	54	54	54
R-squared	0.375	0.499	0.399	0.573	0.470	0.470	0.698	0.726

Table A15: Effect of climate change on banana production

	(1)	(2)	(3)	(4)	(5)	(6)	a7	a8
ADJ								
L.Ind_prod_Bananes	-0.284**	-0.278*	-0.310**	-0.322**	-0.300**	-0.307**	-0.316**	-0.319**
	(0.137)	(0.146)	(0.119)	(0.127)	(0.128)	(0.126)	(0.148)	(0.152)
LR								
Log_lab_banane	0.108	0.076	0.216	0.241	0.223	0.215	0.181	0.186
	(0.224)	(0.230)	(0.149)	(0.167)	(0.221)	(0.211)	(0.219)	(0.225)
Log_Terre_banane	2.943	4.104	0.773	1.313	1.489	0.765	3.731	4.019
	(3.294)	(3.482)	(3.286)	(3.226)	(3.717)	(3.533)	(4.034)	(4.348)
Log_Fertilisants_banane	-0.237	-0.261	-0.260	-0.374*	-0.275	-0.243	-0.352	-0.375
	(0.274)	(0.292)	(0.166)	(0.215)	(0.246)	(0.229)	(0.270)	(0.304)
log_Capital	0.564**	0.504*	0.576***	0.613***	0.529**	0.569**	0.570**	0.561*
	(0.269)	(0.294)	(0.141)	(0.152)	(0.232)	(0.218)	(0.274)	(0.281)
temp	-0.188	-41.568			2.711	0.007	-26.800	-25.698
	(0.659)	(60.069)			(4.319)	(0.585)	(50.922)	(51.673)
temp2		0.841					0.541	0.540
		(1.222)					(1.033)	(1.045)
pluvio			-0.002	-0.025	0.039	-0.002	-0.028	-0.014
			(0.002)	(0.034)	(0.065)	(0.002)	(0.043)	(0.082)
pluvio2				0.000			0.000	0.000
				(0.000)			(0.000)	(0.000)
temp_pluvio					-0.002			-0.001
					(0.003)			(0.003)
SR								
D.Log_lab_banane	0.097	0.106	0.196*	0.213*	0.186	0.183	0.207	0.208
	(0.127)	(0.131)	(0.110)	(0.116)	(0.120)	(0.119)	(0.131)	(0.135)
LD.Log_lab_banane	-0.036	-0.010	-0.021	-0.068	-0.003	-0.007	-0.016	-0.016
	(0.129)	(0.133)	(0.106)	(0.113)	(0.118)	(0.117)	(0.132)	(0.135)
D.Log_Terre_banane	0.916	2.076	0.064	0.152	-0.167	0.083	1.576	1.407
	(2.080)	(2.396)	(1.785)	(1.833)	(1.955)	(1.903)	(2.290)	(2.504)
LD.Log_Terre_banane	2.521	1.406	3.499*	4.095**	3.692*	3.389*	3.128	3.330
	(2.182)	(2.447)	(1.792)	(1.909)	(2.002)	(1.934)	(2.417)	(2.693)
L2D.Log_Terre_banane	1.699	0.477	2.534	2.604	2.154	2.407	1.215	1.214
	(2.232)	(2.496)	(1.869)	(2.001)	(2.125)	(2.074)	(2.533)	(2.588)
D.Log_Fertilisants_banane	0.057	0.022	0.063	0.066	0.065	0.071	0.032	0.030
	(0.078)	(0.083)	(0.064)	(0.072)	(0.081)	(0.080)	(0.092)	(0.094)
D.log_Capital	0.094	0.102	0.130	0.156	0.193	0.114	0.172	0.207
	(0.323)	(0.333)	(0.269)	(0.275)	(0.322)	(0.297)	(0.321)	(0.377)
D.temp	-0.009	5.034			-0.041	-0.037	-0.980	-0.641
	(0.152)	(13.517)			(0.143)	(0.141)	(12.578)	(12.975)
LD.temp	0.026	13.095			-0.023	-0.015	9.239	9.243
	(0.113)	(11.950)			(0.103)	(0.102)	(11.361)	(11.607)
L2D.temp	-0.003	10.927			-0.031	-0.031	7.424	7.455
	(0.080)	(9.268)			(0.075)	(0.074)	(8.735)	(8.926)
D.temp2		-0.103					0.020	0.013
		(0.275)					(0.255)	(0.264)
LD.temp2		-0.265					-0.187	-0.187
		(0.243)					(0.231)	(0.236)
L2D.temp2		-0.222					-0.151	-0.152
		(0.188)					(0.177)	(0.181)
D.pluvio			0.000	0.006	0.000	0.000	0.008	0.008
			(0.001)	(0.010)	(0.001)	(0.001)	(0.012)	(0.013)
LD.pluvio			0.000	0.006	0.000	0.000	0.007	0.007
			(0.000)	(0.008)	(0.000)	(0.000)	(0.010)	(0.010)
L2D.pluvio			-0.000	-0.001	-0.000	-0.000	0.000	0.001
			(0.000)	(0.006)	(0.000)	(0.000)	(0.008)	(0.008)
L3D.pluvio			-0.000*	-0.001	-0.000*	-0.000	-0.001	-0.001
			(0.000)	(0.003)	(0.000)	(0.000)	(0.004)	(0.005)
D.pluvio2				-0.000			-0.000	-0.000
				(0.000)			(0.000)	(0.000)
LD.pluvio2				-0.000			-0.000	-0.000
				(0.000)			(0.000)	(0.000)
L2D.pluvio2				0.000			-0.000	-0.000
				(0.000)			(0.000)	(0.000)
L3D.pluvio2				0.000			0.000	0.000
				(0.000)			(0.000)	(0.000)
Constant	-5.586	133.724	-1.090	3.162	-22.942	-1.121	102.174	94.593
	(10.484)	(187.707)	(8.812)	(11.824)	(33.714)	(9.843)	(183.219)	(191.461)
Observations	55	55	54	54	54	54	54	54
R-squared	0.263	0.316	0.502	0.555	0.515	0.508	0.613	0.614

Table A16: Effect of climate change on millet production

	(1)	(2)	(3)	(4)	(5)	(6)	a7	a8
ADJ								
L.Ind_prod_Mil_Sorgho	-0.489**	-0.566**	-0.382**	-0.308*	-0.360*	-0.361**	-0.286	-0.333
	(0.183)	(0.218)	(0.166)	(0.154)	(0.178)	(0.176)	(0.225)	(0.223)
LR								
Log_lab_Mil_sorgho	-0.004	-0.051	0.006	0.135	0.192	0.182	-0.153	0.233
	(0.241)	(0.220)	(0.206)	(0.329)	(0.400)	(0.390)	(0.435)	(0.563)
Log_Terre_Mil_sorgho	-5.337	-3.398	-10.036	-10.906	-10.446	-11.329	-5.004	-7.211
	(4.219)	(4.092)	(7.636)	(8.995)	(9.154)	(9.003)	(13.285)	(12.876)
Log_Fertilisants_Mil_sorgho	-0.106	-0.110	0.040	-0.036	-0.157	-0.110	0.197	-0.411
	(0.331)	(0.296)	(0.296)	(0.434)	(0.472)	(0.445)	(0.545)	(0.638)
log_Capital	0.627*	0.519	0.865**	0.930**	0.673	0.725	0.722	0.690
	(0.347)	(0.334)	(0.331)	(0.420)	(0.471)	(0.451)	(0.747)	(0.628)
temp	0.413	-40.751			3.865	0.681	-93.147	-6.673
	(0.857)	(62.629)			(8.594)	(1.256)	(100.592)	(117.530)
temp2		0.835					1.881	0.306
		(1.272)					(2.040)	(2.313)
pluvio			-0.000	-0.015	0.046	-0.002	0.013	0.099
			(0.003)	(0.074)	(0.127)	(0.004)	(0.107)	(0.176)
pluvio2				0.000			-0.000	0.000
				(0.000)			(0.000)	(0.000)
temp_pluvio					-0.002			-0.005
					(0.005)			(0.007)
SR								
LD.Ind_prod_Mil_Sorgho	-0.310*	-0.264	-0.436**	-0.460**	-0.479**	-0.484**	-0.457**	-0.469**
	(0.170)	(0.189)	(0.171)	(0.177)	(0.190)	(0.187)	(0.220)	(0.217)
L2D.Ind_prod_Mil_Sorgho	-0.454***	-0.435***	-0.374**	-0.244	-0.468**	-0.449**	-0.194	-0.284
	(0.145)	(0.155)	(0.152)	(0.164)	(0.193)	(0.184)	(0.235)	(0.235)
D.Log_lab_Mil_sorgho	-0.186	-0.164	-0.319	-0.143	-0.273	-0.278	-0.146	-0.096
	(0.275)	(0.289)	(0.252)	(0.234)	(0.277)	(0.273)	(0.274)	(0.269)
LD.Log_lab_Mil_sorgho	-0.073	-0.042	-0.016	-0.101	-0.087	-0.092	-0.008	-0.140
	(0.284)	(0.299)	(0.250)	(0.232)	(0.283)	(0.278)	(0.286)	(0.289)
D.Log_Terre_Mil_sorgho	3.558	3.088	4.715	2.485	4.810	5.135	3.349	-0.082
	(4.717)	(5.446)	(4.279)	(3.899)	(4.658)	(4.516)	(4.751)	(5.108)
LD.Log_Terre_Mil_sorgho	7.155	7.655	4.263	4.975	5.806	5.248		9.140
	(4.991)	(5.537)	(4.376)	(4.012)	(5.053)	(4.773)		(5.378)
L2D.Log_Terre_Mil_sorgho	8.256	8.312	6.330	5.626	6.534	6.760		6.793
	(5.195)	(5.802)	(4.505)	(4.164)	(5.126)	(5.020)		(5.123)
D.Log_Fertilisants_Mil_sorgho	0.051	0.066	0.067	0.159	0.109	0.117	0.117	0.171
	(0.176)	(0.193)	(0.149)	(0.147)	(0.189)	(0.185)	(0.197)	(0.198)
D.log_Capital	-0.076	-0.095	-0.742	-0.580	-0.565	-0.682	-0.708	-0.331
	(0.716)	(0.746)	(0.629)	(0.572)	(0.763)	(0.690)	(0.652)	(0.759)
D.temp	-0.074	7.849			-0.077	-0.070	9.735	-2.137
	(0.319)	(32.248)			(0.329)	(0.324)	(27.997)	(29.185)
LD.temp	-0.118	-3.022			-0.119	-0.106	9.194	-10.392
	(0.241)	(27.510)			(0.240)	(0.235)	(23.476)	(25.533)
L2D.temp	-0.023	4.638			-0.058	-0.061	14.791	0.277
	(0.172)	(20.891)			(0.174)	(0.172)	(17.997)	(19.336)
D.temp2		-0.161					-0.194	0.044
		(0.655)					(0.569)	(0.592)
LD.temp2		0.058					-0.182	0.213
		(0.558)					(0.476)	(0.517)
L2D.temp2		-0.095					-0.298	-0.004
		(0.424)					(0.364)	(0.392)
D.pluvio			0.001	0.004	0.001	0.001	-0.001	0.006
			(0.001)	(0.019)	(0.001)	(0.001)	(0.025)	(0.025)
LD.pluvio			0.002*	0.022	0.002*	0.002*	0.021	0.026
			(0.001)	(0.016)	(0.001)	(0.001)	(0.021)	(0.021)
L2D.pluvio			0.001	0.016	0.001	0.001	0.017	0.020
			(0.001)	(0.012)	(0.001)	(0.001)	(0.017)	(0.017)
L3D.pluvio			0.000	0.003	0.000	0.000	0.002	0.000
			(0.000)	(0.007)	(0.001)	(0.000)	(0.010)	(0.010)
D.pluvio2				-0.000			0.000	-0.000
				(0.000)			(0.000)	(0.000)
LD.pluvio2				-0.000			-0.000	-0.000
				(0.000)			(0.000)	(0.000)
L2D.pluvio2				-0.000			-0.000	-0.000
				(0.000)			(0.000)	(0.000)
L3D.pluvio2				-0.000			-0.000	-0.000
				(0.000)			(0.000)	(0.000)
Constant	21.119	301.336	37.042	35.686	3.163	34.557	339.243	22.464
	(22.241)	(470.641)	(22.681)	(26.882)	(85.217)	(24.885)	(467.736)	(484.621)
Observations	55	55	54	54	54	54	54	54
R-squared	0.564	0.585	0.682	0.782	0.695	0.693	0.786	0.823

Table A17: Effect of climate change on oilseed production

	(1)	(2)	(3)	(4)	(5)	(6)	a7	a8
ADJ								
L.Ind_prod_Oleagineux	-0.267***	-0.387***	-0.283***	-0.264***	-0.299***	-0.284***	-0.300**	-0.322**
	(0.084)	(0.111)	(0.088)	(0.094)	(0.089)	(0.090)	(0.140)	(0.136)
LR								
Log_lab_oleagineux	-0.072	-0.144	-0.192	-0.315	0.010	0.032	-0.226	-0.164
	(0.228)	(0.155)	(0.162)	(0.251)	(0.238)	(0.256)	(0.247)	(0.253)
Log_Terre_oleagineux	-7.427*	-5.474*	-11.939**	-11.821*	-13.345**	-11.270**	-8.617	-14.645*
	(3.744)	(2.732)	(5.160)	(5.810)	(5.166)	(5.151)	(6.852)	(8.202)
Log_Fertilisants_oleagineux	-0.007	0.075	0.131	0.284	0.003	-0.078	0.260	0.369
	(0.331)	(0.219)	(0.259)	(0.393)	(0.323)	(0.346)	(0.357)	(0.396)
log_Capital	1.085***	0.946***	1.477***	1.413***	1.263***	1.119***	0.763	0.976**
	(0.334)	(0.240)	(0.256)	(0.291)	(0.329)	(0.334)	(0.446)	(0.387)
temp	0.794	-84.472*			-7.230	1.145	-93.770	-37.881
	(0.909)	(49.432)			(6.128)	(0.998)	(77.790)	(84.133)
temp2		1.724*					1.928	0.523
		(1.003)					(1.569)	(1.787)
pluvio			-0.003	0.050	-0.130	-0.004	0.080	-0.102
			(0.003)	(0.070)	(0.094)	(0.003)	(0.089)	(0.120)
pluvio2				-0.000			-0.000	-0.000
				(0.000)			(0.000)	(0.000)
temp_pluvio					0.005			0.008
					(0.004)			(0.006)
SR								
LD.Ind_prod_Oleagineux	-0.360**	-0.296*	-0.305*	-0.312*	-0.443**	-0.354**	-0.347	-0.500**
	(0.150)	(0.162)	(0.157)	(0.167)	(0.173)	(0.163)	(0.203)	(0.211)
L2D.Ind_prod_Oleagineux							-0.151	
							(0.244)	
D.Log_lab_oleagineux	0.135	0.160	0.171	0.176	0.144	0.156	0.148	0.108
	(0.148)	(0.145)	(0.161)	(0.174)	(0.164)	(0.166)	(0.187)	(0.178)
LD.Log_lab_oleagineux	0.065	0.111	0.095	0.109	0.097	0.089	0.157	0.117
	(0.158)	(0.158)	(0.160)	(0.173)	(0.168)	(0.170)	(0.204)	(0.193)
D.Log_Terre_oleagineux	4.160	2.010	3.469	3.158	5.554*	4.246	1.923	4.125
	(2.636)	(2.742)	(2.842)	(2.981)	(3.004)	(2.895)	(3.456)	(3.589)
LD.Log_Terre_oleagineux	2.798	3.303	2.812	2.532	2.100	3.064		1.216
	(2.646)	(2.702)	(2.804)	(3.064)	(2.897)	(2.855)		(3.532)
L2D.Log_Terre_oleagineux	1.329	3.004	2.158	1.293	3.315	2.489		4.409
	(2.739)	(2.869)	(2.924)	(3.211)	(3.065)	(3.052)		(3.479)
D.Log_Fertilisants_oleagineux	-0.087	-0.081	-0.146	-0.171	-0.058	-0.060	-0.065	-0.047
	(0.093)	(0.096)	(0.097)	(0.111)	(0.113)	(0.115)	(0.143)	(0.130)
D.log_Capital	-0.337	-0.357	-0.399	-0.364	-0.540	-0.279	-0.193	-0.716
	(0.390)	(0.380)	(0.406)	(0.425)	(0.463)	(0.429)	(0.467)	(0.525)
D.temp	-0.237	20.415			-0.333	-0.329	19.706	2.745
	(0.176)	(19.133)			(0.197)	(0.200)	(22.860)	(22.691)
LD.temp	-0.209	2.394			-0.253*	-0.269*	7.342	-8.861
	(0.131)	(16.041)			(0.142)	(0.144)	(19.388)	(18.957)
L2D.temp	-0.128	-4.423			-0.171	-0.161	-1.953	-15.321
	(0.095)	(11.532)			(0.105)	(0.106)	(13.908)	(14.039)
D.temp2		-0.418					-0.407	-0.064
		(0.388)					(0.463)	(0.460)
LD.temp2		-0.052					-0.155	0.174
		(0.325)					(0.393)	(0.384)
L2D.temp2		0.087					0.036	0.306
		(0.234)					(0.282)	(0.284)
D.pluvio			0.001	-0.010	0.001	0.001	-0.020	-0.026
			(0.001)	(0.014)	(0.001)	(0.001)	(0.017)	(0.017)
LD.pluvio			0.000	-0.006	0.001	0.001	-0.016	-0.018
			(0.001)	(0.012)	(0.001)	(0.001)	(0.014)	(0.014)
L2D.pluvio			0.000	-0.003	0.000	0.000	-0.009	-0.013
			(0.000)	(0.008)	(0.000)	(0.000)	(0.011)	(0.011)
L3D.pluvio			0.000	-0.004	0.000	0.000	-0.005	-0.004
			(0.000)	(0.005)	(0.000)	(0.000)	(0.007)	(0.006)
D.pluvio2				0.000			0.000	0.000
				(0.000)			(0.000)	(0.000)
LD.pluvio2				0.000			0.000	0.000
				(0.000)			(0.000)	(0.000)
L2D.pluvio2				0.000			0.000	0.000
				(0.000)			(0.000)	(0.000)
L3D.pluvio2				0.000			0.000	0.000
				(0.000)			(0.000)	(0.000)
Constant	9.192	416.378	25.603**	12.941	84.739	17.232	343.558	209.032
	(11.252)	(297.785)	(12.384)	(18.747)	(50.424)	(13.726)	(396.929)	(378.353)
Observations	55	55	54	54	54	54	54	54
R-squared	0.426	0.521	0.402	0.442	0.502	0.470	0.555	0.636

Table A18: Effect of climate change on rice production

	(1)	(2)	(3)	(4)	(5)	(6)	a7	a8
ADJ								
L.Ind_prod_Riz paddy	-0.337**	-0.623***	-0.328**	-0.337**	-0.251	-0.340**	-0.567**	-0.585**
	(0.144)	(0.171)	(0.145)	(0.152)	(0.162)	(0.156)	(0.257)	(0.226)
LR								
Log_lab_riz	-0.658	-0.848***	-0.020	-0.280	-0.332	-0.417	-0.870***	-0.787**
	(0.424)	(0.194)	(0.381)	(0.412)	(0.682)	(0.504)	(0.293)	(0.289)
Log_Terre_riz	0.693	12.583***	-6.976	-7.995	-4.808	-6.479	13.393*	14.867**
	(8.966)	(3.662)	(12.808)	(13.101)	(16.517)	(12.935)	(6.771)	(6.669)
Log_Fertilisants_riz	0.840	0.717**	0.223	0.517	0.332	0.637	0.736*	0.592
	(0.600)	(0.270)	(0.523)	(0.653)	(0.941)	(0.664)	(0.367)	(0.455)
log_Capital	1.303*	0.513	0.884	0.770	1.298	1.355	0.625	0.523
	(0.743)	(0.329)	(0.535)	(0.526)	(1.040)	(0.801)	(0.496)	(0.453)
temp	-2.419	-236.919***			24.679	-1.698	-275.546***	-246.744***
	(1.650)	(57.906)			(26.972)	(1.824)	(95.728)	(76.616)
temp2		4.776***					5.552***	5.076***
		(1.176)					(1.933)	(1.578)
pluvio			-0.008	0.072	0.400	-0.006	-0.020	0.042
			(0.006)	(0.117)	(0.417)	(0.007)	(0.019)	(0.145)
pluvio2				-0.000			0.000	0.000
				(0.000)			(0.000)	(0.000)
temp_pluvio					-0.016			-0.003
					(0.017)			(0.006)
SR								
D.Log_lab_riz	0.186	0.337	0.331	0.317	0.268	0.263	0.446	0.480
	(0.351)	(0.300)	(0.373)	(0.384)	(0.386)	(0.396)	(0.356)	(0.376)
LD.Log_lab_riz	-0.402	-0.086	-0.584	-0.696*	-0.467	-0.450	-0.145	-0.191
	(0.366)	(0.319)	(0.372)	(0.386)	(0.392)	(0.402)	(0.388)	(0.406)
D.Log_Terre_riz	6.043	5.655	5.046	5.408	1.784	4.545	5.729	3.446
	(5.913)	(5.467)	(6.258)	(6.303)	(6.623)	(6.561)	(7.226)	(7.176)
LD.Log_Terre_riz	-0.019	-4.821	2.824	2.537	3.531	1.394	-3.716	-2.116
	(6.143)	(5.555)	(6.242)	(6.483)	(6.549)	(6.576)	(6.783)	(7.514)
L2D.Log_Terre_riz	5.335	1.615	9.080	7.207	5.614	7.705	1.635	1.125
	(6.194)	(5.731)	(6.293)	(6.508)	(6.817)	(6.863)	(6.840)	(7.059)
D.Log_Fertilisants_riz	-0.015	-0.237	0.171	0.017	0.016	0.041	-0.286	-0.311
	(0.223)	(0.196)	(0.215)	(0.239)	(0.264)	(0.271)	(0.302)	(0.267)
D.log_Capital	-2.080**	-1.730**	-1.971**	-1.945**	-1.553	-2.226**	-1.629*	-1.227
	(0.890)	(0.748)	(0.913)	(0.916)	(1.049)	(0.987)	(0.894)	(1.079)
D.temp	0.398	68.112			0.208	0.280	69.649	65.763
	(0.424)	(41.168)			(0.473)	(0.482)	(49.762)	(48.496)
LD.temp	0.396	62.637**			0.241	0.318	60.016	58.824
	(0.314)	(30.552)			(0.339)	(0.344)	(42.113)	(37.088)
L2D.temp	0.101	32.770			0.098	0.096	32.620	32.798
	(0.221)	(23.363)			(0.244)	(0.250)	(27.510)	(28.194)
D.temp2		-1.372					-1.402	-1.324
		(0.834)					(1.008)	(0.982)
LD.temp2		-1.261**					-1.208	-1.185
		(0.620)					(0.853)	(0.752)
L2D.temp2		-0.661					-0.658	-0.661
		(0.474)					(0.558)	(0.572)
D.pluvio			0.002	-0.031	0.001	0.002	-0.001	0.005
			(0.002)	(0.032)	(0.002)	(0.002)	(0.002)	(0.034)
LD.pluvio			0.002	-0.026	0.001	0.001	-0.001	0.002
			(0.001)	(0.026)	(0.002)	(0.002)	(0.001)	(0.027)
L2D.pluvio			0.001	-0.029	0.000	0.001	-0.001	-0.001
			(0.001)	(0.019)	(0.001)	(0.001)	(0.001)	(0.022)
L3D.pluvio			0.000	-0.011	-0.000	-0.000	-0.001	0.002
			(0.001)	(0.011)	(0.001)	(0.001)	(0.001)	(0.013)
D.pluvio2				0.000				-0.000
				(0.000)				(0.000)
LD.pluvio2				0.000				-0.000
				(0.000)				(0.000)
L2D.pluvio2				0.000				0.000
				(0.000)				(0.000)
L3D.pluvio2				0.000				-0.000
				(0.000)				(0.000)
LD.Ind_prod_Riz paddy							-0.099	
							(0.230)	
L2D.Ind_prod_Riz paddy							-0.095	
							(0.195)	
Constant	15.696	1769.415***	20.220	2.382	-143.679	31.515	1889.732**	1704.057**
	(26.269)	(575.049)	(27.990)	(39.039)	(112.101)	(30.704)	(693.406)	(763.723)
Observations	55	55	54	54	54	54	54	54
R-squared	0.364	0.606	0.370	0.462	0.450	0.403	0.661	0.676

Table A19: Effect of climate change on tuber production

	(1)	(2)	(3)	(4)	(5)	(6)	a7	a8
ADJ								
L.Ind_prod_Tubercules	-0.206***	-0.206**	-0.203**	-0.190**	-0.210**	-0.214***	-0.073	-0.167
	(0.074)	(0.099)	(0.076)	(0.078)	(0.078)	(0.078)	(0.110)	(0.110)
LR								
Log_lab_tubercules	0.160	0.146	-0.109	-0.155	0.239	0.232	1.390	0.275
	(0.223)	(0.245)	(0.149)	(0.215)	(0.245)	(0.240)	(2.565)	(0.421)
Log_Terre_tubercules	-3.858	-2.482	-7.870	-7.402	-5.682	-7.600*	-20.262	-3.473
	(3.281)	(3.375)	(4.675)	(5.119)	(4.702)	(4.379)	(31.688)	(6.917)
Log_Fertilisants_tubercules	0.050	0.032	0.207	0.319	-0.229	-0.156	-0.812	-0.281
	(0.278)	(0.267)	(0.245)	(0.361)	(0.319)	(0.301)	(1.667)	(0.542)
log_Capital	0.566*	0.493	1.098***	1.039***	0.506	0.613*	0.148	0.365
	(0.324)	(0.331)	(0.207)	(0.242)	(0.348)	(0.315)	(1.261)	(0.550)
temp	1.144	-17.242			8.175	1.629	361.272	35.608
	(0.856)	(68.848)			(6.181)	(0.972)	(752.250)	(122.468)
temp2		0.375					-7.202	-0.460
		(1.391)					(15.066)	(2.334)
pluvio			-0.002	0.023	0.095	-0.004	0.031	0.169
			(0.003)	(0.059)	(0.089)	(0.003)	(0.062)	(0.184)
pluvio2				-0.000			-0.000	-0.000
				(0.000)			(0.000)	(0.000)
temp_pluvio					-0.004			-0.007
					(0.004)			(0.007)
SR								
D.Log_lab_tubercules	0.273***	0.274***	0.245**	0.222*	0.243**	0.238**	0.239**	0.215*
	(0.100)	(0.096)	(0.108)	(0.113)	(0.108)	(0.109)	(0.101)	(0.110)
LD.Log_lab_tubercules	-0.052	-0.041	-0.031	0.017	-0.053	-0.059	-0.015	-0.023
	(0.105)	(0.107)	(0.108)	(0.113)	(0.111)	(0.111)	(0.115)	(0.125)
D.Log_Terre_tubercules	1.049	1.710	0.230	0.321	0.108	0.535	0.624	-0.145
	(1.666)	(1.792)	(1.796)	(1.833)	(1.803)	(1.787)	(1.824)	(2.086)
LD.Log_Terre_tubercules	-0.321	0.106	-0.534	-1.069	0.619	0.105	1.732	1.490
	(1.735)	(1.817)	(1.797)	(1.893)	(1.834)	(1.804)	(1.879)	(2.195)
L2D.Log_Terre_tubercules	-0.010	-1.034	-0.362	-0.539	0.185	0.585	0.025	-0.798
	(1.765)	(1.854)	(1.843)	(1.938)	(1.919)	(1.910)	(1.978)	(2.070)
D.Log_Fertilisants_tubercules	-0.041	-0.024	-0.076	-0.057	-0.002	0.007	0.091	0.035
	(0.062)	(0.062)	(0.062)	(0.070)	(0.074)	(0.074)	(0.075)	(0.078)
D.log_Capital	-0.286	-0.320	-0.445	-0.473	-0.189	-0.322	-0.318	-0.183
	(0.263)	(0.255)	(0.276)	(0.281)	(0.302)	(0.285)	(0.269)	(0.327)
D.temp	-0.207*	-2.290			-0.287**	-0.283**	-23.704	-5.017
	(0.116)	(12.158)			(0.130)	(0.131)	(14.657)	(12.993)
LD.temp	-0.178**	-5.848			-0.224**	-0.213**	-26.169**	-11.968
	(0.088)	(9.741)			(0.094)	(0.094)	(12.175)	(10.522)
L2D.temp	-0.082	7.361			-0.094	-0.095	-5.715	4.672
	(0.063)	(7.006)			(0.070)	(0.071)	(8.704)	(7.545)
D.temp2		0.042					0.473	0.096
		(0.247)					(0.297)	(0.264)
LD.temp2		0.114					0.525**	0.238
		(0.198)					(0.246)	(0.213)
L2D.temp2		-0.151					0.112	-0.097
		(0.142)					(0.176)	(0.153)
D.pluvio			0.000	0.001	0.001	0.001	0.001*	0.002
			(0.000)	(0.009)	(0.001)	(0.001)	(0.001)	(0.010)
LD.pluvio			0.000	0.000	0.000	0.001	0.001	0.000
			(0.000)	(0.008)	(0.000)	(0.000)	(0.000)	(0.008)
L2D.pluvio			0.000	0.003	0.000	0.000	0.000	0.003
			(0.000)	(0.005)	(0.000)	(0.000)	(0.000)	(0.006)
L3D.pluvio			-0.000	0.001	-0.000	0.000	0.000	0.001
			(0.000)	(0.003)	(0.000)	(0.000)	(0.000)	(0.004)
D.pluvio2				-0.000				-0.000
				(0.000)				(0.000)
LD.pluvio2				-0.000				-0.000
				(0.000)				(0.000)
L2D.pluvio2				-0.000				-0.000
				(0.000)				(0.000)
L3D.pluvio2				-0.000				-0.000
				(0.000)				(0.000)
LD.Ind_prod_Tubercules							-0.339*	
							(0.197)	
L2D.Ind_prod_Tubercules							-0.162	
							(0.149)	
Constant	0.788	44.844	13.978	8.452	-30.553	7.043	-316.330	-94.521
	(8.179)	(187.648)	(9.756)	(12.929)	(31.605)	(10.182)	(225.878)	(219.789)
Observations	55	55	54	54	54	54	54	54
R-squared	0.454	0.550	0.361	0.435	0.480	0.454	0.650	0.655

Table A20: Effect of climate change on cereal production

	(1)	(2)	(3)	(4)	(5)	(6)	a7	a8
ADJ								
L.Ind_prod_autres_Cereales	-0.171	-0.150	-0.161	-0.163	-0.154	-0.153	-0.058	-0.071
	(0.109)	(0.157)	(0.103)	(0.106)	(0.112)	(0.110)	(0.165)	(0.194)
LR								
Log_lab_autres_cereales	0.117	0.156	0.207	0.179	0.336	0.342	1.796	1.230
	(0.409)	(0.613)	(0.361)	(0.398)	(0.599)	(0.597)	(6.291)	(4.473)
Log_Terre_autres _cereales	-15.405	-18.104	-21.640	-21.037	-23.451	-22.722	-70.850	-53.343
	(10.372)	(20.576)	(14.632)	(14.656)	(17.967)	(17.199)	(211.091)	(157.135)
Log_Fertilisants_autres _cereales	0.166	0.153	0.175	0.215	0.126	0.090	-0.530	-0.245
	(0.453)	(0.493)	(0.364)	(0.486)	(0.553)	(0.540)	(2.528)	(1.865)
log_Capital	1.584**	1.896	1.771**	1.687**	1.728*	1.689**	4.331	3.522
	(0.674)	(1.400)	(0.710)	(0.683)	(0.856)	(0.819)	(10.640)	(7.790)
temp	0.014	78.061			-2.526	0.453	476.865	322.919
	(1.162)	(216.693)			(9.713)	(1.490)	(1709.969)	(1236.834)
temp2		-1.590					-9.661	-6.573
		(4.402)					(34.640)	(25.189)
pluvio			-0.003	0.008	-0.049	-0.003	-0.111	-0.084
			(0.004)	(0.082)	(0.148)	(0.005)	(0.321)	(0.464)
pluvio2				-0.000			0.000	0.000
				(0.000)			(0.000)	(0.000)
temp_pluvio					0.002			0.001
					(0.006)			(0.018)
SR								
LD.Ind_prod_autres_Cereales	-0.537***	-0.653***	-0.575***	-0.538***	-0.593***	-0.593***	-0.803***	-0.761***
	(0.152)	(0.168)	(0.153)	(0.173)	(0.166)	(0.164)	(0.182)	(0.215)
L2D.Ind_prod_autres_Cereales	-0.554***	-0.628***	-0.492***	-0.371**	-0.509***	-0.516***	-0.592***	-0.497**
	(0.140)	(0.144)	(0.144)	(0.166)	(0.163)	(0.159)	(0.166)	(0.218)
D.Log_lab_autres_cereales	-0.153	-0.168	-0.205	-0.160	-0.186	-0.185	-0.186	-0.167
	(0.132)	(0.128)	(0.131)	(0.138)	(0.143)	(0.141)	(0.132)	(0.152)
LD.Log_lab_autres_cereales	-0.008	-0.033	0.015	-0.013	-0.014	-0.011	-0.115	-0.087
	(0.138)	(0.136)	(0.130)	(0.137)	(0.145)	(0.143)	(0.142)	(0.163)
D.Log_Terre_autres _cereales	1.893	2.093	1.753	0.830	2.115	1.990	1.542	1.020
	(2.338)	(2.422)	(2.289)	(2.396)	(2.495)	(2.426)	(2.401)	(2.896)
LD.Log_Terre_autres _cereales	0.625	2.442	0.241	0.663	0.238	0.420	3.278	3.081
	(2.380)	(2.444)	(2.250)	(2.377)	(2.517)	(2.412)	(2.435)	(2.941)
L2D.Log_Terre_autres _cereales	1.694	2.511	1.963	2.076	2.001	1.871	3.251	3.227
	(2.437)	(2.515)	(2.308)	(2.433)	(2.611)	(2.539)	(2.550)	(2.808)
D.Log_Fertilisants_autres _cereales	0.016	0.018	0.044	0.037	0.066	0.062	0.073	0.073
	(0.086)	(0.088)	(0.078)	(0.088)	(0.100)	(0.098)	(0.100)	(0.115)
D.log_Capital	-0.168	-0.099	-0.458	-0.415	-0.467	-0.422	-0.258	-0.278
	(0.357)	(0.352)	(0.333)	(0.340)	(0.403)	(0.371)	(0.348)	(0.433)
D.temp	0.019	-23.273			-0.013	-0.014	-33.236*	-31.300
	(0.155)	(17.919)			(0.171)	(0.169)	(18.179)	(20.730)
LD.temp	-0.041	-24.232			-0.048	-0.052	-33.687**	-30.650*
	(0.117)	(14.429)			(0.124)	(0.122)	(15.243)	(17.354)
L2D.temp	-0.006	-12.598			-0.029	-0.029	-16.411	-13.892
	(0.083)	(10.112)			(0.091)	(0.090)	(10.467)	(12.364)
D.temp2		0.473					0.674*	0.635
		(0.364)					(0.369)	(0.420)
LD.temp2		0.491					0.682**	0.621*
		(0.293)					(0.309)	(0.351)
L2D.temp2		0.255					0.333	0.282
		(0.205)					(0.212)	(0.250)
D.pluvio			0.001	-0.005	0.001	0.001	0.001	-0.001
			(0.001)	(0.011)	(0.001)	(0.001)	(0.001)	(0.015)
LD.pluvio			0.001*	-0.000	0.001	0.001	0.001	0.003
			(0.000)	(0.009)	(0.001)	(0.001)	(0.001)	(0.012)
L2D.pluvio			0.001	0.000	0.001	0.001	0.001	0.004
			(0.000)	(0.007)	(0.000)	(0.000)	(0.000)	(0.010)
L3D.pluvio			0.000	-0.002	0.000	0.000	0.000	0.001
			(0.000)	(0.004)	(0.000)	(0.000)	(0.000)	(0.006)
D.pluvio2				0.000				0.000
				(0.000)				(0.000)
LD.pluvio2				0.000				-0.000
				(0.000)				(0.000)
L2D.pluvio2				0.000				-0.000
				(0.000)				(0.000)
L3D.pluvio2				0.000				-0.000
				(0.000)				(0.000)
Constant	19.156*	-124.418	26.376**	24.621*	37.093	24.746**	-304.862	-250.523
	(9.562)	(275.591)	(9.720)	(14.353)	(41.045)	(11.150)	(298.086)	(360.504)
Observations	55	55	54	54	54	54	54	54
R-squared	0.564	0.646	0.633	0.677	0.644	0.643	0.753	0.763

Table A21: Effect of climate change on fruit production

	(1)	(2)	(3)	(4)	(5)	(6)	a7	a8
ADJ								
L.Ind_prod_Fruits	-0.179*	-0.224*	-0.166*	-0.155	-0.173*	-0.172*	-0.256*	-0.280**
	(0.092)	(0.122)	(0.093)	(0.094)	(0.094)	(0.092)	(0.132)	(0.104)
LR								
Log_lab_fruits	-0.041	-0.034	-0.208	-0.070	-0.158	-0.159	-0.155	-0.208
	(0.202)	(0.172)	(0.167)	(0.218)	(0.230)	(0.228)	(0.170)	(0.131)
Log_Terre_fruits	0.688	-0.147	4.871	4.991	5.132	4.807	3.329	5.866
	(4.020)	(3.090)	(6.851)	(7.504)	(6.881)	(6.520)	(4.386)	(3.823)
Log_Fertilisants_fruits	-0.378	-0.270	-0.406	-0.583	-0.372	-0.362	-0.216	-0.121
	(0.402)	(0.328)	(0.392)	(0.563)	(0.431)	(0.421)	(0.307)	(0.231)
log_Capital	0.890***	0.840***	0.995***	1.102***	0.837**	0.856***	0.791***	1.002***
	(0.295)	(0.253)	(0.232)	(0.306)	(0.323)	(0.307)	(0.231)	(0.214)
temp	0.525	-20.767			1.539	0.343	-44.781	-72.667**
	(0.793)	(55.280)			(5.698)	(0.858)	(48.051)	(33.463)
temp2		0.430					0.913	1.499**
		(1.120)					(0.973)	(0.673)
pluvio			0.003	-0.057	0.021	0.002	-0.002	-0.040
			(0.003)	(0.069)	(0.086)	(0.003)	(0.012)	(0.061)
pluvio2				0.000			0.000	0.000*
				(0.000)			(0.000)	(0.000)
temp_pluvio					-0.001			-0.001
					(0.003)			(0.002)
SR								
LD.Ind_prod_Fruits	-0.093	-0.138	-0.132	-0.091	-0.139	-0.137	-0.179	-0.055
	(0.136)	(0.144)	(0.137)	(0.146)	(0.144)	(0.141)	(0.161)	(0.139)
L2D.Ind_prod_Fruits	-0.459***	-0.421***	-0.488***	-0.518***	-0.487***	-0.494***	-0.439***	-0.299**
	(0.134)	(0.139)	(0.132)	(0.146)	(0.142)	(0.137)	(0.152)	(0.137)
D.Log_lab_fruits	0.013	0.027	0.026	0.013	-0.008	-0.009	0.016	0.011
	(0.087)	(0.089)	(0.091)	(0.096)	(0.094)	(0.093)	(0.098)	(0.080)
LD.Log_lab_fruits	0.096	0.084	0.096	0.110	0.129	0.129	0.119	0.192**
	(0.090)	(0.093)	(0.090)	(0.094)	(0.094)	(0.092)	(0.101)	(0.083)
D.Log_Terre_fruits	-0.787	-2.386	-1.145	-0.855	-1.085	-1.012	-2.743	-2.258
	(1.490)	(1.743)	(1.606)	(1.654)	(1.645)	(1.582)	(1.967)	(1.725)
LD.Log_Terre_fruits	0.949	1.321	1.021	0.869	0.906	0.813	1.091	0.398
	(1.542)	(1.748)	(1.538)	(1.605)	(1.631)	(1.547)	(1.857)	(1.614)
L2D.Log_Terre_fruits	-0.074	0.723	-0.524	-0.124	-0.764	-0.716	-0.089	-0.803
	(1.599)	(1.771)	(1.606)	(1.679)	(1.696)	(1.654)	(1.976)	(1.558)
D.Log_Fertilisants_fruits	0.134**	0.167***	0.109*	0.130**	0.143**	0.145**	0.160**	0.138**
	(0.055)	(0.059)	(0.054)	(0.060)	(0.066)	(0.065)	(0.073)	(0.058)
D.log_Capital	0.002	-0.037	0.149	0.158	0.141	0.124	0.078	0.104
	(0.240)	(0.247)	(0.246)	(0.250)	(0.268)	(0.252)	(0.271)	(0.235)
D.temp	-0.143	6.272			-0.142	-0.141	8.246	10.040
	(0.102)	(11.726)			(0.113)	(0.111)	(12.482)	(9.954)
LD.temp	-0.081	-4.742			-0.085	-0.083	-1.507	-0.605
	(0.078)	(9.721)			(0.083)	(0.081)	(10.484)	(8.215)
L2D.temp	-0.080	-4.554			-0.101	-0.102	-2.173	1.371
	(0.056)	(6.995)			(0.061)	(0.060)	(7.470)	(5.951)
D.temp2		-0.130					-0.170	-0.204
		(0.238)					(0.253)	(0.202)
LD.temp2		0.094					0.029	0.011
		(0.197)					(0.213)	(0.166)
L2D.temp2		0.091					0.042	-0.028
		(0.142)					(0.152)	(0.121)
D.pluvio			-0.001	0.007	-0.001	-0.001	-0.001	0.015**
			(0.000)	(0.008)	(0.000)	(0.000)	(0.001)	(0.007)
LD.pluvio			-0.001	0.003	-0.000	-0.000	-0.001	0.009
			(0.000)	(0.006)	(0.000)	(0.000)	(0.000)	(0.006)
L2D.pluvio			-0.000*	0.004	-0.000*	-0.000*	-0.001*	0.012**
			(0.000)	(0.005)	(0.000)	(0.000)	(0.000)	(0.005)
L3D.pluvio			-0.000	0.003	-0.000	-0.000	-0.000	0.010***
			(0.000)	(0.003)	(0.000)	(0.000)	(0.000)	(0.003)
D.pluvio2				-0.000				-0.000**
				(0.000)				(0.000)
LD.pluvio2				-0.000				-0.000
				(0.000)				(0.000)
L2D.pluvio2				-0.000				-0.000**
				(0.000)				(0.000)
L3D.pluvio2				-0.000				-0.000***
				(0.000)				(0.000)
Constant	-2.834	56.290	-4.169	3.026	-10.927	-5.520	137.257	252.829
	(4.812)	(171.421)	(4.083)	(8.042)	(25.826)	(5.062)	(191.125)	(155.496)
Observations	55	55	54	54	54	54	54	54
R-squared	0.521	0.575	0.539	0.599	0.607	0.606	0.651	0.830

Table A22: Effect of climate change on other productions

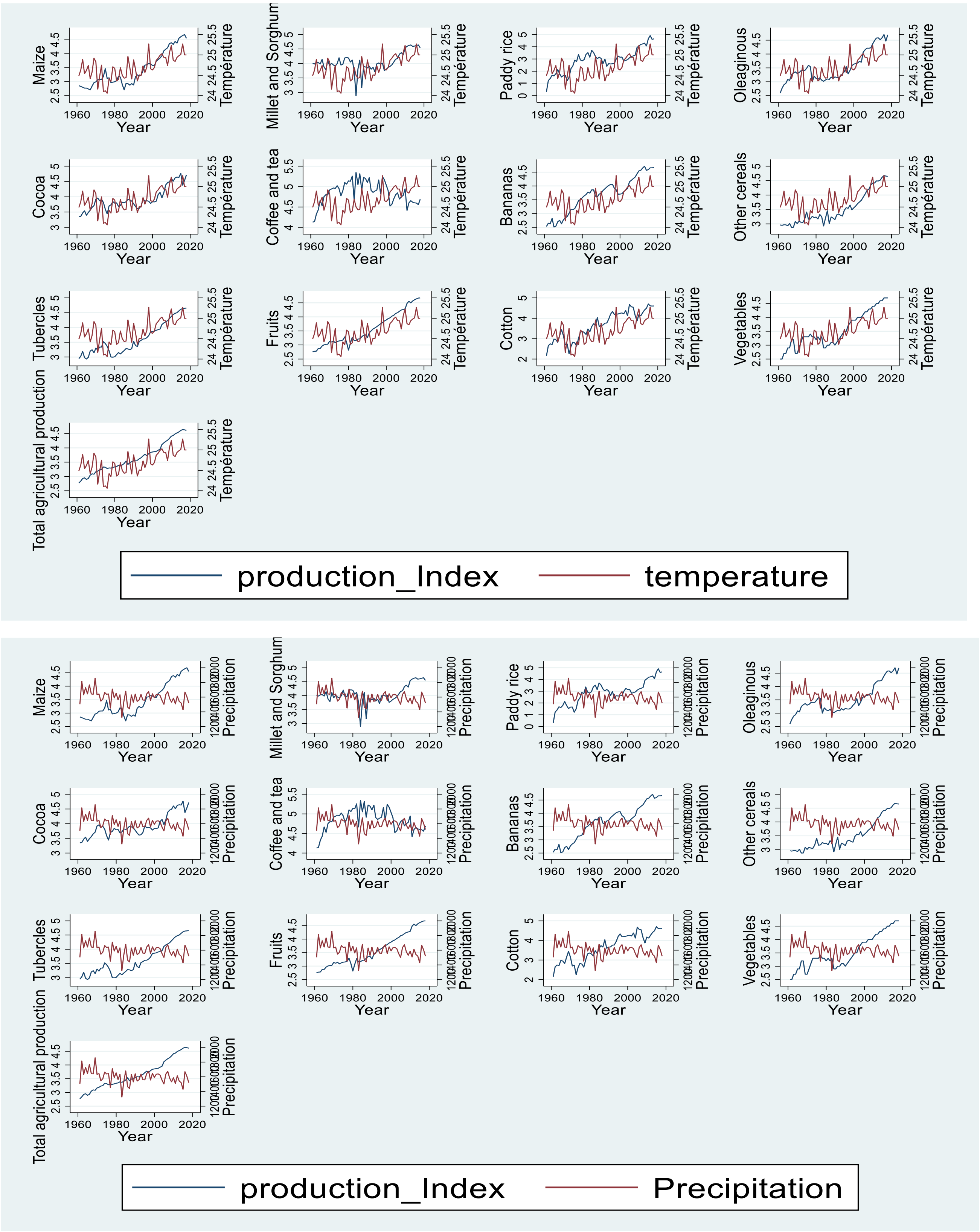
	(1)	(2)	(3)	(4)	(5)	(6)	a7	a8
ADJ								
L.Ind_prod__total	-0.145**	-0.165**	-0.141**	-0.102*	-0.143**	-0.143**	-0.178**	-0.090
	(0.057)	(0.079)	(0.056)	(0.054)	(0.060)	(0.059)	(0.079)	(0.084)
LR								
Log_lab_tot	0.056	0.030	0.053	0.219	0.052	0.056	-0.029	0.312
	(0.141)	(0.132)	(0.152)	(0.281)	(0.178)	(0.175)	(0.135)	(0.549)
Log_Terre_tot	-4.231	-3.724	-5.881	-8.819	-5.970	-5.750	-4.052	-10.147
	(2.684)	(2.746)	(3.859)	(6.135)	(4.043)	(3.822)	(3.288)	(11.244)
Log_Fertilisants_tot	0.162	0.152	0.158	0.211	0.148	0.139	0.172	0.195
	(0.172)	(0.163)	(0.162)	(0.262)	(0.186)	(0.179)	(0.157)	(0.362)
log_Capital	0.706***	0.674***	0.854***	0.899***	0.831***	0.812***	0.731***	0.545
	(0.211)	(0.206)	(0.158)	(0.224)	(0.249)	(0.229)	(0.195)	(0.432)
temp	0.251	-26.542			-0.727	0.139	-41.053	-15.526
	(0.469)	(39.112)			(3.747)	(0.487)	(33.304)	(79.608)
temp2		0.543					0.834	0.331
		(0.794)					(0.677)	(1.583)
pluvio			-0.001	0.035	-0.014	-0.001	0.011	0.088
			(0.002)	(0.047)	(0.056)	(0.002)	(0.010)	(0.158)
pluvio2				-0.000			-0.000	-0.000
				(0.000)			(0.000)	(0.000)
temp_pluvio					0.001			0.000
					(0.002)			(0.004)
SR								
D.Log_lab_tot	0.044	0.042	0.065	0.153**	0.058	0.057	0.067	0.141**
	(0.051)	(0.052)	(0.060)	(0.063)	(0.063)	(0.062)	(0.063)	(0.066)
D.Log_Terre_tot	1.684**	1.094	1.163	0.706	1.332	1.316	0.146	0.191
	(0.827)	(0.973)	(0.851)	(0.820)	(0.905)	(0.890)	(1.053)	(1.051)
D.Log_Fertilisants_tot	-0.039	-0.037	-0.054*	-0.040	-0.059	-0.057	-0.064*	-0.033
	(0.033)	(0.036)	(0.029)	(0.031)	(0.037)	(0.036)	(0.036)	(0.042)
D.log_Capital	-0.189	-0.233	-0.201	-0.172	-0.234	-0.224	-0.301**	-0.217
	(0.133)	(0.142)	(0.130)	(0.123)	(0.149)	(0.141)	(0.145)	(0.160)
D.temp	-0.062	2.228			-0.041	-0.043	2.923	-0.397
	(0.058)	(6.003)			(0.062)	(0.060)	(5.824)	(5.773)
LD.temp	-0.004	1.083			0.014	0.012	1.317	0.490
	(0.044)	(4.552)			(0.048)	(0.046)	(4.403)	(4.299)
L2D.temp	-0.017	4.148			-0.013	-0.014	4.556	2.670
	(0.032)	(3.481)			(0.033)	(0.032)	(3.480)	(3.517)
D.temp2		-0.047					-0.060	0.007
		(0.122)					(0.118)	(0.117)
LD.temp2		-0.022					-0.026	-0.010
		(0.093)					(0.089)	(0.087)
L2D.temp2		-0.085					-0.093	-0.055
		(0.071)					(0.071)	(0.071)
D.pluvio			-0.000	-0.001	0.000	0.000	-0.000	-0.005
			(0.000)	(0.004)	(0.000)	(0.000)	(0.000)	(0.005)
LD.pluvio			-0.000	-0.002	0.000	0.000	-0.000	-0.004
			(0.000)	(0.003)	(0.000)	(0.000)	(0.000)	(0.004)
L2D.pluvio			-0.000	-0.002	-0.000	-0.000	-0.000	-0.004
			(0.000)	(0.002)	(0.000)	(0.000)	(0.000)	(0.003)
L3D.pluvio			-0.000	-0.003**	-0.000	-0.000	-0.000*	-0.005**
			(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.002)
D.pluvio2				0.000				0.000
				(0.000)				(0.000)
LD.pluvio2				0.000				0.000
				(0.000)				(0.000)
L2D.pluvio2				0.000				0.000
				(0.000)				(0.000)
L3D.pluvio2				0.000**				0.000**
				(0.000)				(0.000)
Constant	5.492	59.982	8.901	6.698	11.861	8.483	95.973	19.862
	(4.533)	(93.652)	(5.501)	(5.669)	(15.592)	(5.908)	(92.559)	(101.479)
Observations	55	55	54	54	54	54	54	54
R-squared	0.350	0.390	0.397	0.537	0.457	0.456	0.555	0.661

p < 0.10, ** p < 0.05, *** p < 0.01

Table A23: Effect of climate change on cotton production

	(1)	(2)	(3)	(4)	(5)	(6)	a7	a8
ADJ								
L.Ind_prod_Coton_graine	-0.434***	-0.462***	-0.483***	-0.393**	-0.454**	-0.475***	-0.395**	-0.226
	(0.138)	(0.150)	(0.151)	(0.154)	(0.171)	(0.161)	(0.180)	(0.184)
LR								
Log_lab_coton	-0.278	-0.207	-0.271*	-0.575**	-0.352	-0.343	-0.408	-0.425
	(0.251)	(0.238)	(0.147)	(0.279)	(0.264)	(0.247)	(0.343)	(0.563)
Log_Terre_Coton	4.978	3.322	7.929*	7.163	8.358	7.557	2.705	11.934
	(4.076)	(4.145)	(4.578)	(5.243)	(5.590)	(4.843)	(6.622)	(14.618)
Log_Fertilisants_Coton	0.270	0.279	0.244	0.707*	0.323	0.343	0.593	0.052
	(0.339)	(0.320)	(0.233)	(0.392)	(0.343)	(0.320)	(0.457)	(0.812)
log_Capital	0.466	0.542	0.303	0.094	0.383	0.413	-0.024	-0.672
	(0.358)	(0.356)	(0.197)	(0.270)	(0.349)	(0.322)	(0.496)	(1.212)
temp	-0.181	76.392			2.050	-0.368	84.511	132.091
	(0.917)	(66.452)			(6.546)	(0.879)	(79.344)	(144.363)
temp2		-1.553					-1.697	-1.935
		(1.351)					(1.606)	(2.647)
pluvio			0.002	0.131	0.040	0.002	0.169	0.756
			(0.003)	(0.086)	(0.100)	(0.003)	(0.113)	(0.752)
pluvio2				-0.000			-0.000	-0.000
				(0.000)			(0.000)	(0.000)
temp_pluvio					-0.001			-0.022
					(0.004)			(0.024)
SR								
D.Log_lab_coton	-0.147	-0.166	-0.265	-0.337	-0.263	-0.261	-0.396	-0.361
	(0.255)	(0.257)	(0.251)	(0.240)	(0.271)	(0.268)	(0.266)	(0.247)
LD.Log_lab_coton	0.473*	0.431	0.576**	0.680***	0.601**	0.592**	0.608**	0.645**
	(0.258)	(0.261)	(0.242)	(0.234)	(0.265)	(0.260)	(0.269)	(0.250)
D.Log_Terre_Coton	-6.805	-6.594	-4.485	-4.247	-4.807	-4.675	-4.376	-6.875
	(4.465)	(5.043)	(4.364)	(4.075)	(4.677)	(4.602)	(4.977)	(4.757)
LD.Log_Terre_Coton	-2.963	-0.328	-5.102	-5.484	-4.453	-5.078	-2.178	3.736
	(4.570)	(4.917)	(4.436)	(4.296)	(4.973)	(4.646)	(5.050)	(5.417)
L2D.Log_Terre_Coton	-2.830	-2.674	-4.849	-5.555	-5.515	-5.376	-4.175	-3.866
	(4.529)	(4.926)	(4.462)	(4.228)	(4.865)	(4.787)	(5.033)	(4.671)
D.Log_Fertilisants_Coton	0.271*	0.349**	0.296*	0.179	0.278	0.279	0.297	0.288
	(0.158)	(0.166)	(0.152)	(0.154)	(0.189)	(0.186)	(0.191)	(0.178)
D.log_Capital	-0.242	-0.394	-0.199	-0.160	-0.276	-0.380	-0.442	0.446
	(0.643)	(0.652)	(0.612)	(0.571)	(0.720)	(0.659)	(0.646)	(0.725)
D.temp	0.179	-20.097			0.209	0.211	-16.428	-3.079
	(0.304)	(27.178)			(0.322)	(0.318)	(25.573)	(24.503)
LD.temp	0.134	-31.633			0.151	0.160	-19.847	-14.671
	(0.226)	(23.731)			(0.234)	(0.229)	(22.860)	(21.339)
L2D.temp	0.053	-4.409			-0.009	-0.007	-4.459	1.072
	(0.159)	(19.016)			(0.172)	(0.169)	(18.441)	(17.294)
D.temp2		0.411					0.331	0.060
		(0.552)					(0.519)	(0.497)
LD.temp2		0.644					0.403	0.297
		(0.482)					(0.464)	(0.433)
L2D.temp2		0.090					0.088	-0.023
		(0.386)					(0.374)	(0.351)
D.pluvio			-0.001	-0.051**	-0.001	-0.001	-0.061**	-0.052**
			(0.001)	(0.020)	(0.001)	(0.001)	(0.024)	(0.022)
LD.pluvio			0.000	-0.040**	-0.000	-0.000	-0.046**	-0.039**
			(0.001)	(0.016)	(0.001)	(0.001)	(0.019)	(0.018)
L2D.pluvio			-0.000	-0.020*	-0.000	-0.000	-0.029*	-0.022
			(0.001)	(0.012)	(0.001)	(0.001)	(0.015)	(0.014)
L3D.pluvio			0.000	-0.013*	0.000	0.000	-0.020**	-0.024**
			(0.000)	(0.007)	(0.000)	(0.000)	(0.009)	(0.009)
D.pluvio2				0.000**			0.000**	0.000**
				(0.000)			(0.000)	(0.000)
LD.pluvio2				0.000**			0.000**	0.000**
				(0.000)			(0.000)	(0.000)
L2D.pluvio2				0.000*			0.000*	0.000
				(0.000)			(0.000)	(0.000)
L3D.pluvio2				0.000*			0.000**	0.000**
				(0.000)			(0.000)	(0.000)
Constant	-15.557	-446.704	-31.797	-63.365**	-55.306	-26.440	-475.623	-528.688
	(18.168)	(393.426)	(20.073)	(24.563)	(77.186)	(22.457)	(392.582)	(364.988)
Observations	55	55	54	54	54	54	54	54
R-squared	0.417	0.477	0.509	0.638	0.536	0.534	0.699	0.752

Graph A24: Changes in climate (temperature and precipitation) and in production



Source: The authors.