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Impact of Climate Change on Global Agriculture: Impact Map

By Assaad Ghazouani & Hedia Teraoui
Al-Nahrain University

Summary- Our main focus in this article is to evaluate individually, that is to say, at the level of every country, the impact of climate change on agriculture. The objectif at this level is to set a new world map of the impact of climate change on global agriculture. Our analysis is mainly concerned with impulse response functions as this instrument enables us to synthesize the essential information contained in the dynamics of the estimated VAR system and ECM. Impulse response functions, enabled us to determine the nature of the effects of different shocks on different variables and being based on this instrument one could distinguish 4 large country families on a new global map by type of climate impact.

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Strictly as per the compliance and regulations of :

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Assaad Ghazouani [α] & Hedia Teraoui [σ]

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I. Introduction

The uncontrolled growth in greenhouse gas emissions is warming the planet, with the consequences of melting glaciers, increased precipitation, more frequent extreme weather events, and shifting seasons. The acceleration of climate change, combined with the growth in population and income globally, threatens food security everywhere.

Agriculture is extremely sensitive to climate change. Higher temperatures reduce yields of desirable crops while causing a proliferation of weeds and pests. The change in precipitation patterns increase the likelihood of poor harvests on the Short-term and a long term decline in production. Although some regions of the world can register an improvement of some of their crops, climate change will generally have negative impacts on agriculture and will threaten food security globally.

Bearing this in mind, in this article we seek to evaluate individually, that is to say, by country, the impact of climate change on agriculture. The goal at this level is to see how agriculture in each country of the world will be affected by climate change? And in which direction will it evolve ?

The answer to these questions will be developed in four sections: The first section will be devoted to a review of the empirical literature, the second section will be devoted to the derivation of the model to estimate and presentation of data to operate. At the third section is the exposure of the actual methodology and empirical analysis to be developed and the fourth section will be reserved for d'estimations results, the key recommendations and the presentation of the impact world map.

II. Literature Review

To study climate change, economists (mainly economists working in the IPCC) often refer to the study of change in the climate state. This is to say the change in the state of climate that can be measured by using either a:

- Statistical tools such as tests, calculating averages, variances, …
- Observing, for a long period, typically decades or more, changes in the properties of the climate itself.

Regarding the study of climate change impacts on agriculture, theorists are not unanimous as to the nature of these effects and some others and are a minority, saw a positive impact; others, wich from the majority, rather see negative impacts. However the impact on agriculture is rather based on the physiological characteristics of the region suffering the climate change and in production cultures.

The climate change impact studies on agriculture had covered the globe: Africa, Europe, Asia, America and Australia. Many authors have highlighted the effects of climate change:

In a study of econometric time series, VA Alexandrov and G. Hoogenboom (2000) studied Bulgaria during the last decade of the twentieth c., the impact of climate variability. These authors confirmed the theories developed above; they claim that they alone, natural climate variations can not explain the drop in agricultural production, other anthropogenic factors contribute to explaining the variability of this production.

Monirul and Mirza (2002) calculated the increased risk of crop losses in Bangladesh following the increase in the frequency of flooding. they concluded that agriculture in Bangladesh is vulnerable to climate change, particularly to flooding due to heavy rainfall and / or cyclones.

The overall results advanced by these authors conceal an enormous variability depending on whether the area is in Africa or Latin America. Furthermore Peter G. Jonesa and Philip K. Thornton (2003) recommend an emergency assessment of climate change at the household level, so that the poor and vulnerable people

Author α σ: Laboratory of Economics and Applied Finance (LEAF), IHEC Carthage, Tunisia. e-mail: ghazouani_assaad@yahoo.fr

dependent on agriculture can be targeted appropriately in activities research and development.

Rashid Hassan (2010) in a study on the impact of climate change on African agriculture could demonstrate a close relationship between these two variables; He demonstrated particularly how climate change has shaped African agriculture in the past and how it will lead in the future, an impact on African agricultural economies; the author relies on the awareness of African farmers to draw effective adaptation strategies.

For Shilong, P. et al, (2010) China with 7% of arable land is required to feed about a quarter of the world population (22%); Yet despite its explosive economic growth the past decade, the Chinese economy remains vulnerable to climate change including global warming that will impact the Chinese water resources for agriculture and therefore will compact its ability to feed its population.

Nkulumo Zinyengere et al (2014) have evaluated the impact of climate change on agriculture in southern Africa, their study examined how climate change may affect different food crops in specific locations in the region. Corn and sorghum in the Mohale Hoek in Lesotho and Swaziland Big Bend. corn and peanuts in Lilongwe, Malawi).

The study confirmed that the impact of climate change on crop yields in southern Africa vary according to places and cultures. Despite various uncertainties associated with these evaluations, the results showed that crop yields are expected to decrease at Big Bend (corn (-20%), sorghum (-16%)) and Lilongwe (maize (- 5%) I groundnut (-33%)). However, crop yields in Hoek Mohale, located in a high altitude area historically prone to yield losses of cold-related crops are expected to increase (maize (+ 8%) and sorghum (+ 51%)).

III. Methodology and Data

a) Model specification

[Y] production is based on three factors of production: land or natural resources [T] which, in the rest of the article, is assimilated to the performance of agriculture, capital [K] and work [L] [F] means the technology used in the combination of production factors and [u] is a term that takes into account factors overlooked in empirical studies or econometric model.

$$Y=F(X1, X2,\ldots\ldots Xi) = F(T, K, L)(u) \qquad (1)$$

Relation (1) is a non-monetary relationship since binds a Y output volume to input [X1, X2, ..., Xi] volume regardless of prices or production costs.
The total differential expression (1) gives us :

$$dY = \frac{\partial F}{\partial T}dT + \frac{\partial F}{\partial K}dK + \frac{\partial F}{\partial L}dL \Leftrightarrow dY = F_T dT + F_K dK + F_L Dl \qquad (2)$$

$$\frac{dY}{Y} = e(Y,T)\frac{dT}{T} + e(Y,K)\frac{dK}{K} + e(Y,L)\frac{dL}{L} \qquad (3)$$

$$Y = e^h T^\theta K^\alpha L^\beta \qquad (4)$$

- *h* refers to the integration constant,
- $\alpha = e(Y, K)$,
- $\beta = e(Y, L)$,
- $\theta = e(Y,T)$ represent the partial elasticities of output with respect to each factor,
- e^h corresponds to a scalar technology [scale factor productivity index or size factor].

Being inspired by the work of Richard SJ Tol (2005), Long. C et al (2010), Dell. M et al (2008), Nelson. G C et al (2014) and Lecocq. F Shalizi. Z (2007) can be rewritten as the integration constant [s] so that it integrates climate change :

$$h = \delta CC \text{ Where}$$

- δ is an indicator that measures the direct effect of climate change on agriculture and economic growth.
- CC is an indicator of climate change

$$\Rightarrow e^h = e^{\delta CC} \Rightarrow Y_t = F(K_t, L_t, T_t) = e^{\delta CC} K_t^\alpha L_t^\beta A_t^\theta \quad (5)$$

Where A = T (Agriculture In is the product of the earth T)

$$\theta = \mu_0 + \mu_1 CC$$

- μ_0 is an indicator that measures the contribution of the agricultural sector to the production in the absence of climate change. $\mu_0 \succ 0$: Improved agricultural productivity is expected to positively affect production.
- μ_1 is an indicator that measures the indirect effect of climate change on the production CC. $\mu_1 < 0$: A climate change reduces agricultural output which in turn slows growth.

$$\Rightarrow Y_t = e^{\delta CC} K_t^\alpha L_t^\beta A_t^\theta = e^{\delta CC} K_t^\alpha L_t^\beta A_t^{\mu_0 + \mu_1 CC} \qquad (7)$$

To calculate the Y growth rate as a function of growth rate K, L and A, we use the following property (8) :

$$g_Y = \frac{\dot{Y}}{Y} = \frac{\partial \ln f(t)}{\partial t} \quad (8)$$

$$\ln Y = \delta CC + \alpha \ln K_t + \beta \ln L_t + \theta \ln A_t \quad (9)$$

$$\Leftrightarrow \frac{\Delta Y_t}{Y_t} = \alpha \frac{\Delta K_t}{K_t} + \beta \frac{\Delta L_t}{L_t} + \mu_0 \frac{\Delta A_t}{A_t} + \mu_1 \frac{\Delta A_t}{A_t} CC \quad (10)$$

The specification (10) estimates the contribution of agriculture to the growth process by highlighting the role of climate change. In the following section, we will present the empirical analysis and results.

To study the impact of climate change on agriculture, we used equation (10), an equation that describes the relationship between climate change, agriculture and GDP.

The evaluation of the effect of a climate shock on dynamic long and short term, will be via a MCE type of modeling (model error correction) or VAR (Vector Autoregressive). The interaction between climate change (CC) agricultural output (A) and GDP (Y) can be analyzed through the following multivariate model:

$$[Y_t = A_t + CC_t]$$

Where :
Y: the Gross Domestic Product,
A = agricultural output,
CC = climate change indicator

b) Data

The data to use in the empirical analysis concerning 157 countries of the world and are extracted from the database of the World Bank, these data are annual and cover the period which runs from 1980 to 2013.

- Production [Y] is assimilated to GDP. GDP is defined by the World Bank as "the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of products.
- Climate change [CC] is measured by carbon dioxide emissions (CO_2).
- Agricultural output [A] is the ratio between the share of the value added of agriculture in GDP and the total area of arable land.

IV. Empirical Analysis

For each country, the objective is to position and know its impulse response function following a climate shock. Knowing the impulse response model assumes estimating a VAR model or ECM; To do this we will need analysis in terms of Co-integration analysis is applicable only on stationary series. Thus the empirical analysis in this article will follow the following five steps:

1. Testing the stationarity of the series.
2. Determing the number of optimal delay
3. Analyzing the relationship of cointegration.
4. Estimating ECM or a VAR model.
5. Analyzing the impulse response function,

a) Tests of stationarity

Models used as a basis for the construction of the Dickey-Fuller Increases (ADF) are three in number and they are based on the assumption | $\Phi 1$ | <1, the OLS estimation of the three models:

$$\text{Model 1}: \Delta x_t = \rho x_{t-1} - \sum_{j=2}^{p} \Phi_1 \Delta x_{t-j+1} + \varepsilon_t$$

$$\text{Model 2}: \Delta x_t = \rho x_{t-1} - \sum_{j=2}^{p} \Phi_1 \Delta x_{t-j+1} + c + \varepsilon_t$$

$$\text{Model 3}: \Delta x_t = \rho x_{t-1} - \sum_{j=2}^{p} \Phi_1 \Delta x_{t-j+1} + c + bt + \varepsilon_t$$

With $\varepsilon_{t \to}$ i.i.d

The decision rule is such that:

- if $t^{cal} < t^{tab}$, we reject H0 (H0: the existence of a unit root), the series is stationary in level.
- Si $t^{cal} > t^{tab}$, we accept H0 (H0: the existence of a unit root), the series is not stationary in levels. It is integrated of order 1: I (1) or higher order 1.

b) Number of lags

The number of lags to consider in a VAR or ECM model is the number h that minimizes the following functions:

$$AIC(\rho) = \ln\left[\det\left|\Sigma_e\right|\right] + \frac{2k^2 \rho}{n}$$

Where :

- Σ_e is the estimate of the covariance matrix of the residuals with the VAR (h) or ECM (h)
- ρ the order of process
- k the number of variables in the system
- n the number of observation

c) Cointegration Test

Two series x_t and y_t are called cointegrated if both conditions are verified :

- They are assigned a stochastic trend similar integration d
- A linear combination of these series makes it possible to bring a series of lower integration order.

whether : $x_t \to I(d)$, $y_t \to I(d)$

such as $\alpha_1 x_t + \alpha_2 y_t \to I(d\text{-}b)$ with $d \geq b > 0$

We note : x_t, $y_t \to CI(d,b)$ where $[\alpha_1 \alpha_2]$ is the vector of cointegration.

In the general case with k variables, we have:

$$x_{1,t} \rightarrow I(d) \quad , \quad x_{2,t} \rightarrow I(d)$$

……… we note $X_t = [x_1, x_2, \ldots, x_{k,t}]$

$$x_{k,t} \rightarrow I(d)$$

If there is a cointegration vector $\alpha = [\alpha_1, \alpha_2, \ldots, \alpha_k]$ de dimension (k,1) such as $\alpha x_t \rightarrow I(d\text{-}b)$, then the k variables are cointegrated and the vector is Cointegration α. We note que $X_t \rightarrow CI\ (d,b)$ avec b > 0.

d) Error Correction Model

ECM combine two categories of variables, non-stationary variables expressed in levels, which are interpreted as determinants of the long-period equilibrium and stationary variables.

Either the model below :

$$y_t = b + \alpha x_t + \varepsilon_t$$

And considering the long-term relationship $y_t = b + \alpha x_t$. We admit that there is a long-term relationship between the variables x_t and y_t that are integrated of ordre 1 with the cointegrating linear combination.

$y_t - b - \alpha x_t = ED \# 0$ that is stationary with ED = error disequilibrium

The coefficients b and a are long-term parameters.

If xt and yt are in balance, ED should be zero. Otherwise, ED is either positive or negative. That is why we talk about error disequilibrium.

Supposing that y_t follows an autoregressive process distributed delays of ordre (1.1) and written :

$$yt \sim AD \qquad (1,1)$$

$$y_t = k + \alpha x_t + \beta x_{t-1} + \gamma y_{t-1} + \varepsilon_t \qquad (1)$$

$$K = \text{constant and } 0 < \gamma < 1$$

Parameterization (1) provides a dynamic representation called ECM

$$y_t - y_{t-1} = k + \alpha x_t + \beta x_{t-1} + (\gamma\text{-}1) y_{t-1}$$

$$\Delta y_t = k + \alpha x_t - \alpha x_{t-1} + \alpha x_{t-1} + \beta x_{t-1} + (\gamma\text{-}1) y_{t-1}$$

$$= \alpha \Delta x_t + (\gamma\text{-}1)[y_{t-1} + \frac{\alpha+\beta}{\gamma-1} x_{t-1} + \frac{k}{\gamma-1}]$$

By reducing the expression (γ-1) à (1-γ) we get:

$$= \alpha \Delta x_t - (1\text{-}\gamma)[y_{t-1} - \frac{\alpha+\beta}{\gamma-1} x_{t-1} - \frac{k}{\gamma-1}]$$

$$= \alpha \Delta x_t - (1\text{-}\gamma)[y_{t-1} - AX_{t-1} - c] \qquad (2)$$

We posing $\frac{\alpha+\beta}{\gamma-1} = A$ et $\frac{k}{\gamma-1} = c$

Equality is called Model 2 has Error Correction (ECM).

α is the short-term impact of Δx_t on Δy_t; (1-γ) is the magnitude of the adjustment

Δy_t imbalance observed in relation to the period spent between x_t and y_t. Since $0 < \gamma < 1$ shows that $0 < (1\text{-}\gamma) < 1$.

Returning to the equilibrium relationship of long period:

$y_t = b + \alpha x_t \rightarrow y_{t-1} - b + \alpha x_{t-1} = ED = 0$ which is the error of imbalance.

If ED = 0, this means that x_t and y_t are in equilibrium. Otherwise, ED> ED 0 or <0. These are the deviations which make us talk about error disequilibrium.

For the calculations, we use the lagging indicator:

$y_{t-1} - b - \alpha x_{t-1}$ = ED (-1) ED called a delayed period. ED Comparison (-1) to the equation (150), this means that A = α and c = b so that the classic formula ECM becomes :

$$\Delta y_t = \alpha \Delta x_t - (1\text{-}\gamma) ED(\text{-}1) = ECM$$

e) AutoRegressive Vector

The VAR is a combination of simultaneous equation models and autoregressive process. They were introduced by Christopher Sims (1980) from a critique based on the analysis of macroeconomic models.

The process $y_t = A + By_{t-1} + U_t$ is a autoregressive vector order 1: it is, it has only one delay and two endogenous variables. This is a simplification of reality; Indeed the modeling of some macroeconomic phenomena, the economist can use several variables and to introduce more than five delays depending on the degree of precision.

To take into account this aspect, I resume the system with n variables and p lags. In other words, we generalize as follows:

$$I \begin{cases} y_{1t} = \alpha_0 + \alpha_{1t} y_{1t-1} + \dots + \alpha_{1p} y_{1t-p} + \dots + \beta_{1p} y_{2t-p} + \dots + \phi_{1t} y_{nt-1} + \phi_{1p} y_{nt-p} + \mu_{1t} \\ y_{2t} = \beta_0 + \alpha_{2t} y_{1t-1} + \dots + \alpha_{2p} y_{1t-p} + \dots + \beta_{2p} y_{2t-p} + \dots + \phi_{2t} y_{nt-1} + \phi_{2p} y_{nt-p} + \mu_{2t} \\ \vdots \\ y_{nt} = \theta_0 + \alpha_{nt} y_{nt-1} + \dots + \alpha_{np} y_{nt-p} + \dots + \beta_{np} y_{2t-p} + \dots + \phi_{nt} y_{nt-1} + \phi_{np} y_{nt-p} + \mu_{nt} \end{cases}$$

We posing $y_t = (y_{1t}, y_{2t}, \ldots, y_{nt})$

$$A= (\alpha_0, \ldots, \beta_0, \ldots, \theta_0)$$

$$y_{t-1} = (y_{1t-1}, y_{2t-1}, \ldots, y_{nt-1})$$

$$y_{t-2} = (y_{1t-2}, y_{2t-2}, \ldots, y_{nt-2})$$

$$\ldots$$

$$y_{t-p} = (y_{1t-p}, y_{2t-p}, \ldots, y_{nt-p})$$

$$U_t = (\mu_{1t}, \mu_{2t}, \ldots, \mu_{nt}) \text{ et}$$

$$B_1 = \begin{bmatrix} \alpha_{11} & \beta_{11} & \cdots & \delta_{11} \\ \alpha_{21} & \beta_{21} & \cdots & \delta_{21} \\ \cdots & \cdots & \cdots & \cdots \\ \alpha_{n1} & \beta_{n1} & \cdots & \delta_{n1} \end{bmatrix}, \ldots, B_p = \begin{bmatrix} \alpha_{1p} & p & \cdots & \delta_{1p} \\ \alpha_{2p} & \beta_{2p} & \cdots & \delta_{2p} \\ \cdots & \cdots & \cdots & \cdots \\ \alpha_{np} & \beta_{np} & \cdots & \delta_{np} \end{bmatrix}$$

The system *I* can write:

$$y_t = A + B_1 y_{t-1} + B_2 y_{t-2} + \ldots + B_p y_{t-p} + U_t$$

This system is the general presentation of an autoregressive vector (with n variables and p lags).

V. Simulations and Results

a) Simulations

The impact of climate change on agriculture study is measured by applying a pulse function rethinks.

i. *The impulse response function*

In general, the analysis of a shock is to measure the impact of changes Due Action (innovation, shock pulse) on variables. For example from the estimated model for Tunisia:

$$Y = 0.853651*Y_{t-1} - 0.042458*A_{t-1} + 0.216834*CC_{t-1} + 0.848176 + e_{1t}$$

$$A = -0.756745*Y_{t-1} + 0.252199*A_{t-1} + 1.451919*CC_{t-1} - 5,604848 + e_{1t}$$

$$CC = 0.354766*Y_{t-1} + 0.089684*A_{t-1} + 0.462537*CC_{t-1} - 1.882922 + e_{2t}$$

A change at a given time of e_{1t} has an immediate consequence on Y_t then A_{t+1} CC_{t+1} for example if there is a shock in t E1T to 1, we have the following impact:

a period t : $\begin{bmatrix} \Delta Y_t \\ \Delta A_t \\ \Delta CC_t \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}$

a period t+1 :

$$\begin{bmatrix} \Delta Y_{t+1} \\ \Delta A_{t+1} \\ \Delta CC_{t+1} \end{bmatrix} = \begin{bmatrix} 0.853651 & -0.042458 & 0.216834 \\ -0.756745 & 0.252199 & 1.451919 \\ 0.354766 & 0.089684 & 0.462537 \end{bmatrix} \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} 0.853651 \\ -0.756745 \\ 0.354766 \end{bmatrix}$$

a period t +2 :

$$\begin{bmatrix} \Delta Y_{t+2} \\ \Delta A_{t+2} \\ \Delta CC_{t+2} \end{bmatrix} = \begin{bmatrix} 0.853651 & -0.042458 & 0.216834 \\ -0.756745 & 0.252199 & 1.451919 \\ 0.354766 & 0.089684 & 0.462537 \end{bmatrix} \begin{bmatrix} 0.853651 \\ -0.756745 \\ 0.354766 \end{bmatrix} = \begin{bmatrix} 0,837791 \\ -0,321754 \\ 0,399070 \end{bmatrix}$$

Etc.…

The various calculated values make up the impulse response function.

b) Results

i. *The new world map*

We present in this section the different model results and MCE VAR specified in previous sections. Our analysis is mainly concerned with impulse response functions, as this instrument allows to synthesize the essential information contained in the dynamics of the estimated VAR system and MCE.

The estimation results enabled us to draw up an impact map of climate change on agriculture in the world (Figure 1). This map shows that climate change will affect different countries of the world. This allowed us to distinguish 4 large country families distributed in the magnitude of the impact:

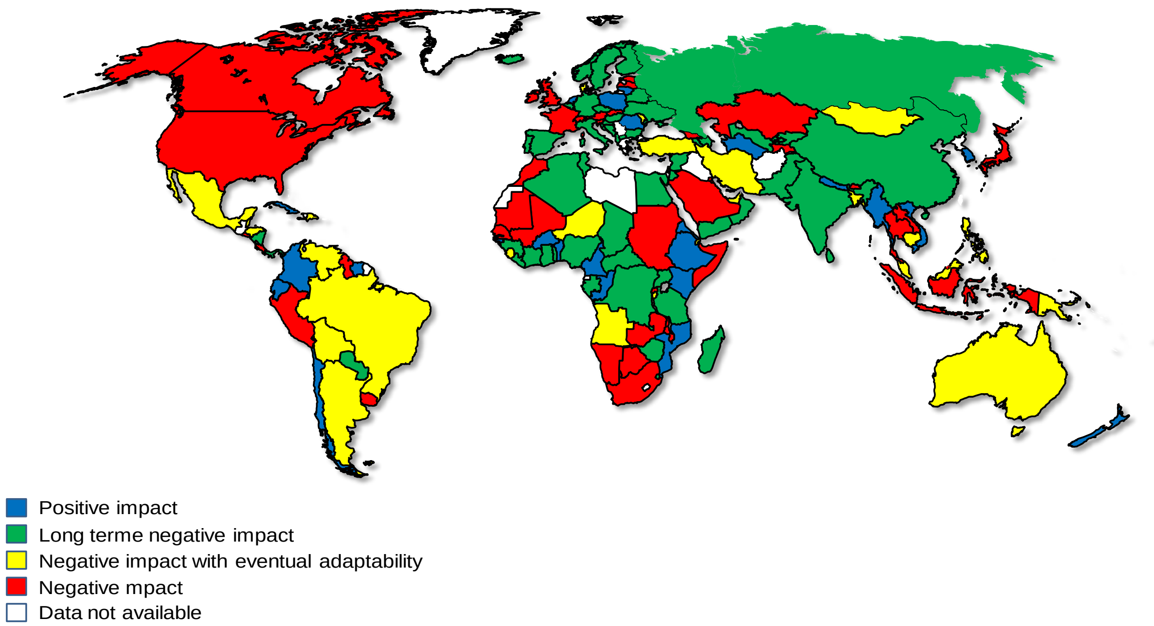
1. Countries whose agriculture is positively affected by climate change: agriculture in this country category will benefit from the CO2 fertilization effect and yield of many crops will increase. since these countries are not major emitters of greenhouse gases, climate extremes will be smaller in terms of impact.
2. Countries that will suffer long-term negative impacts: agriculture in many countries in this category may benefit from climate change and the CO2 fertilization effect at least in the short term. However, most of the regions in Africa, Europe and Asia are expected to save up to 5% of the losses, even with strong CO2 fertilization. These losses increase to 30% if CO2 fertilization effects are omitted. In fact, without CO2 fertilization all regions are expected to experience a loss of productivity due to climate change.
3. Countries that are equipped with a resilience: its countries have great agricultural potential so they can adapt even on the long term. Ingenuity and innovation will be critical in the years ahead in order to produce more food sustainably on less land available. The adaptation includes proven practical techniques such as improved water management, improved pasture, integrated crop-livestock management, crop rotation, conservation agriculture and innovative practices, for example insurance against risk, more resistant food crops and better weather forecasts.
4. Countries negatively affected by climate change: Estimates suggest that the continued rise in CO2 concentrations and the excess in threshold limit will significantly increase global food production losses and cancel the fertilizing effect of CO2 by the end of the century. A change in concentrations of CO2 permanently and negatively affect the climate and increasing the frequency and severity of extreme weather events such as drought, floods, precipitation, cyclones and storms.

Degradation of natural resources is liable to hinder the increase of agricultural productivity and could tarnish the optimistic assessments of the prospects for meeting the growing global demand for food at acceptable environmental cost.

According to the impact map (Figure 1) and the graph of CO2 emissions (Figure 2) shows a correlation between the impact type and amount of carbon dioxide emitted, the more issues more GHG impacts will be more severe. The amount of carbon dioxide in the atmosphere has increased by about 35% since the industrial era and we know that this increase is due to man, mainly from burning fossil fuels. Thus, humankind has dramatically altered the chemical composition of the atmosphere of the planet, with important consequences for the climate.

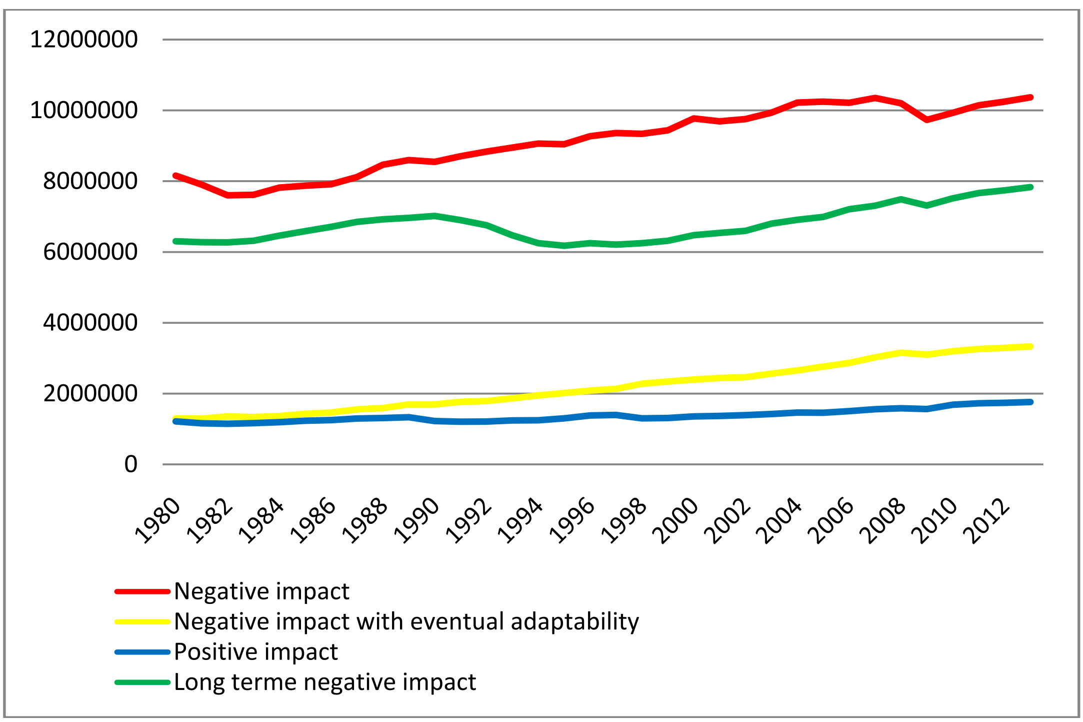
Poor countries and developing countries are generally the most affected by climate change even though they are not large emitters of GHGs, however major global economic and agricultural powers like the US, Canada, Australia, japan or the countries of the European union are not secure and they will experience negative impacts on their agriculture which may destabilize the global market for food products and lead to a future food crisis.

The results of our work supports the overall results made by various studies such as William Cline (2007), Gunter Fisher et al (2005) and the IPCC (the Intergovernmental Panel on Climate Change) (2007, 2014). Climate change has a negative global impact on agriculture.



Source: A.Ghazouani

Figure 1: Impact of climate change on agriculture in the world



Source : A. Ghazouani / WBI

Figure 2: CO2 emission by country group and type of climate impact

Agriculture is extremely vulnerable to climate change. Higher temperatures reduce yields of desirable crops while encouraging the emergence and proliferation of pests and weeds. Changes in precipitation patterns increase the likelihood of poor harvests in the short term and long term production declines.

Although there are gains in some crops in some regions of the world, the overall impacts of climate change on agriculture should be negative, threatening global food security. In developing countries, climate change will cause yield declines for the most important crops. In Asia, Africa and South America. Even developed countries will be particularly affected.

The populations of the developing world, who are already vulnerable to food insecurity, are likely to be the most affected. In 2005, almost half of the economically active population in developing countries or 2.5 billion people, depend on agriculture for their livelihood. Today, 75% of the world's poor live in rural areas.

VI. Conclusion

This paper proposes a model to highlight the impacts of climate change on global agriculture. The empirical results show that:

- Climate change affects in different ways global agriculture, but generally these impacts are negative and are more important for countries to emit more CO2. Further analysis of the impulse response functions for 37 countries shows that climate change is affecting negatively and permanently agricultural output and 77 countries will suffer the same long-term impacts. However, climate change will have positive impacts on agriculture from 20 countries and 23 countries will adapt.
- At the end of our analysis we can say that given the global climate situation and the results that have been reached, it is obvious that steps to be taken in emergency especially for countries affected negatively. And generally for any country in the world even the beneficiaries of favorable weather conditions since if several countries are not major emitters of CO2 they are affected by gas concentrations of greenhouse gases emitted from other countries.
- As it is expected that global GHG concentrations will increase. the world will even be more affected by the emissions and must be other cultural methods cannot be considered to make agricultural lands be more introductive.
- If we cannot quickly adapt and adopt adaptation strategies and to let the pressure that will exert climate change on global agriculture will inevitably lead to a global food crisis, the poorer countries and essentially developing countries will be the most affected and the most severely affected, the crises of 2008 and 2010 are only the beginning in a series of farming setbacks to come.

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