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Climate, International Trade and Crop Biodiversity in West Africa Countries

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Abstract

The aim of this study is to analyze the impact of climate change and international trade on crop biodiversity in West Africa countries. For several years the problem of food security arising in these countries. Climate change (temperature, rainfall), international trade through trade policies that stimulate trade flow, lead to high conversion of land allocated to the production of food for the benefit of agricultural raw materials. This study focuses on the West Africa countries. We use data from FAO, WDI, UNCTAD, CRU data and GPPC database to estimate the impact of climate change and international trade on crop biodiversity through an econometric regression using dynamic panel data. The results find evidence that climate change and trade influence negatively crop diversity. Also find evidence that irrigation and fertilizers use are best way for conservation of crop diversity.

Key Words: climate change, international trade, crop biodiversity.

1. INTRODUCTION

Agricultural biodiversity is key for food production and supply. Thus, the question of agricultural biodiversity conservation is of crucial important for Africa developing countries. For Leveque (1997), biodiversity is important for several economic reasons such as: It contributes to soil fertility and protection, as well as regulation of the hydrological cycle, it is the basis of all agricultural production, it is essential for the improvement of plants and pets, it contributes to the supply of many food products, raw materials for industry, medicine, building materials and household use. The low diversity and availability of agricultural commodities for food in Africa countries, particularly in West Africa could be based on: rising demand, stagnation and decline in supply due to low production capacity and water resources scarcity, low investment in agricultural development, but may also be linked to climate change and international trade.

Biodiversity for food and agriculture include genetic diversity of crop and livestock. Crop biodiversity is thus very important for both the functioning of ecological systems and the generation of a vast array of ecosystem services (e.g., Naeem et al. 1994; Tilman & Downing 1994; Tilman et al. 1996; Wood & Lenné 1999; Loreau & Hector 2001). Africa is home to centers of origin of many cereal crops and tuber crops such as millet, sorghum, African rice, beans, soybean, cowpeas, yams, maize, sweet potato, taro, the peanut and many others. Food diversity (cereals, root and tubers crops) ensure good health and remain a relatively cheap source of nutritional content (Deaton, 1997), generate income, and ensure a sustainable ecology (FAO, 2008). Cereals represent 47% of calorie consumption among individuals in Sub-Saharan Africa and represent 50% of protein consumption among individuals in Sub-Saharan Africa (FAO, 2009). Also Root and tuber crops are the second food commodities consumed in Africa, they are widely grown and consumed as subsistence staples in many parts of Africa. In some parts of Africa the diet is supplemented with the tender leaves of sweet potato, cassava and cocoyam which are rich sources of protein, minerals and vitamins (Hahn, 1984).

Thus the conservation of agricultural biodiversity in Africa countries must remain a challenge for the sustainability of agricultural resources and food security. However, agriculture in Africa is influenced by climate change and international environment such as international trade. According some studies, there is link between climate change and agricultural biodiversity on the one hand (FAO 2008;) and the link between international trade and agricultural biodiversity on other hand (Conway 1998 & UNEP 2010,). Climate change and international trade are considered as global climate change that can influence agriculture production and land conservation.

Increasing temperatures, declining and more unpredictable rainfall, more frequent extreme weather and higher severity of pest and disease are among the more drastic changes that would impact food production (Parry et al. 2007; Kotschi 2007; Morton 2007; Brown & Funk 2008; Lobell et al. 2008). However, global trends mask tremendous regional differences, with the poorest being most at risk both by global climate variations and global commodity price fluctuations (Diaz et al. 2006). Some of the most important effects of global climate change will be felt among smallholder farmers, predominantly in developing countries (Morton 2007). In recent years, Africa suffers from many climatic disturbances among others, changes in temperature and movement of the seasons, the decrease in rainfall, drought and the drying up of streams connected to strong sunlight ...). Studies by the Intergovernmental Panel on Climate Change (IPCC) show that rainfall will decline again in the dry lands of Africa, exacerbating desertification and drought and therefore increasing the upslope of poverty. Also, water scarcity is expected to hit some countries in Africa by 2025 in the case in Benin, Burkina Faso, Niger, Mauritania and Nigeria (IPCC Report 2007).

Also, Trade in agricultural products and trade policies are a major driver of changes in land-use and agricultural practices. While trade offers many opportunities, land use changes and farming practices that lead to a loss of biodiversity and ecosystem services can have immediate impacts on human well-being. Price volatility of agriculture product on the international market leads to a change in agricultural production system. Farm's produce more export or cash crops to the detriment of food crops (cereal crops, root and tuber crops).

While biodiversity for food and agriculture can be significantly affected by climate change, it will also be an important element in the development of production strategies to meet the challenges of climate change. Unfortunately, biodiversity for food and agriculture and climate change have rarely been discussed together. Also in the literature, there are many empirical works focused on the analysis of the impact of climate change on agriculture production in Africa countries on the one hand and the relationship between trade and agriculture on other hand. However, there is lack of empirical studies related on agricultural biodiversity. Our contribution is to discuss together empirically the impact of climate and trade on agricultural biodiversity in global level. Climate change and international trade are considered as global climate change that can influence agriculture production and land conservation.

This paper is organized as follows. In the next section we show the situation of climate change in West Africa and its impact on agricultural biodiversity. In section 3 we present the channels for which trade affect agricultural biodiversity. In section 4 we describe the research methodology and the data used for the analysis. Section 5 presents and discusses the results of the estimations. Finally, section 6 discusses the policy implications of the analyses and offers some recommendations on how the conservation of food and agricultural diversity to face global environment change.

2. CLIMATE CHANGE IN WEST AFRICA AND RELATIONSHIP BETWEEN CLIMATE CHANGE AGRICULTURAL BIODIVERSITY

Climate change is not new to West Africa. West Africa in general and the Sahelian region in particular are characterized by some of the most variable climates on the planet. For some years now, there have been signs that the climate is changing significantly in West Africa. Almost every country in the region has experienced a year-by-year reduction in rainfall. In the northern part of the Sahel, rainfall in the 1970s and 1980s was half the rainfall of the 1950s and 1960s. The whole water cycle was affected, with serious consequences for agriculture and food security. There has been an alteration in the pattern of rainy seasons, and the number of natural disasters has been rising. In 2008 torrential rain led to the flooding of vast cultivated areas and the loss of life, especially in Togo and Ghana. The harmattan, the dry, cold, north-easterly trade wind that blows along the coast of West Africa has weakened, particularly in Benin and Côte d'Ivoire. The increasing disruption of agricultural calendars is wreaking havoc on agricultural planning. Government help still goes no further than vague and incoherent statements, and farmers and extension workers are left to cope as best they can (Odefi & Grain, 2009).

Also, atmospheric concentrations of CO_2 stabilize at around 600 ppm by the end of the century, leading to a global temperature rise of around 1.8°C and a sea level rise of 18 to 38 cm over the next 100 years. The temperature rise would lead to a 20–30 per cent decrease in water availability in some vulnerable regions of the world. Crop yields would decline across tropical regions and would fall by five to 10 per cent in Africa. According (Easterling, 1996), in developing countries, 11 percent of arable land could be affected by climate change, including a reduction of cereal production in up to 65 countries which is about 16 percent of agricultural GDP. Planned crops selection and distribution strategies across different agroclimatic zones, substitution of new crops for old ones and resource substitution induced by scarcity are already taking place.

It is also very likely that climate change will affect the ecosystem services in this region provided by agricultural biodiversity. An increase in temperature may also reduce the area suitable for some crop species in certain regions, while it may expand the areas in other regions. Many rain-fed crops in tropical areas may approach their maximum temperature tolerance if temperature increases. Global warming will create new climates, changing where, how, and what crops farmers will be able to cultivate. As climate change brings new pest and diseases, new resistances will be required for animal breeds, fish breeds and crop and forest varieties. Genetic diversity which is currently underutilized may become more attractive to farmers as a result of climate change.

To face these challenges farmers will have to rely on adapted genetic resources, and need technological, political and information support to reinforce and improve their ability to select, maintain, and exchange genetic resources that will be adapted and adaptable to new climatic conditions and guarantee sustainability of the world's food, fibre and energy production.

3. TRADE AND AGRICULTURAL BIODIVERSITY

The importance of understanding the complex relationships that link agriculture, biodiversity and trade has been acknowledged by the Convention on Biological Diversity (CBD)[1]. As a general framework, Article 14 of the CBD calls on States to "introduce appropriate arrangements to ensure that the environmental consequences of its programmes and policies that are likely to have significant adverse impacts on biological diversity are duly taken into account." More specifically addressing the context of trade, the CBD Conference of Parties (COP) has called for the impact of trade liberalization on agricultural biodiversity to be studied in cooperation with international organizations, including UNEP (Decision VI/5)[2].

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[1] Convention on Biological Diversity, 5 June 1992: http://www.cbd.int/convention/convention.shtml

[2] Convention on Biological Diversity (2006) Agricultural Biological Diversity. COP Decision VI/5, http://www.cbd.int/decision/cop/?id=7179

In light of the complex relationship between agricultural production and biological diversity, coupled with the difficulty in forwarding robust data-grounded coefficients, estimating the extent to which trade affects biodiversity on an aggregate basis must rely largely on stylized observations. Despite the obvious problems of assigning clear causal links between trade liberalization and biological diversity, a useful starting point is to examine the extent of trade restrictions and distortions in the agricultural sector, extrapolate probable impacts of liberalization on changes in relative prices, and then extrapolate further how changes in relative prices alter the allocation of resources within and between markets CDB (2002).

In which channel international trade influence agriculture biodiversity? Trade in agricultural products is a major driver of changes in land-use and agricultural practices. While trade offers many opportunities, land-use changes and farming practices that lead to a loss of biodiversity and ecosystem services can have immediate impacts on human well-being. Governments regulate trade flows using trade policies, which cover many areas including import tariffs and quotas, export taxes, subsidies and a variety of non-tariff barriers to trade in goods or services. Changes in these trade-related measures influence the cost structures and potential revenues that farmers and farming companies use as a basis for their production decisions, which affects the relative intensity of various factors of agricultural production, such as land, soil, labor, as well as inputs, such as fertilizers and pesticides. This, in turn, can have significant impacts on various aspects of biodiversity, such as food crop diversity, biodiversity in adjacent ecosystems (for example, through run off and agrochemicals), and biodiversity located on land previously under alternative use (the cut down forest). In addition to price, trade policies can give rise to other types of change, such as conditions for foreign direct investment, market access, credit availability, intellectual property rights, and standards and labeling.

Trade policies and agreements are mostly driven by economic goals and international agendas for trade liberalization and regional economic integration. The social and environmental impacts of these policies are then addressed separately in domestic policymaking. National policies that govern the conservation and sustainable use of biodiversity (through, *inter alia*, land-use planning, protected areas, regulation of chemicals use, support structures for sustainable agriculture, pollution control), therefore, play an important role in providing some boundaries and safeguards for the economic driving forces.

4. METHODOLOGY

4.1. Model specification

In most studies on the determinants of crop diversity in farm-level (Van Dusen 2000; Benin et al. 2004 ; Di Falco et al. 2010); Crop diversity depend on conventional agricultural inputs (labor, capital and land), land characteristics (soil fertility and slope), population change and climatic factors… In the case of our study, to investigate the impact of climate change and international trade on crop biodiversity in West-Africa countries, we specify a dynamic panel data model where for any country i and at time t crop biodiversity depend on crop diversity in past period and variables described above.

$$D_{it} = \alpha D_{i\,t-1} + \beta climate_{it} + \gamma trade_{it} + \sum_j \lambda_j X_{jt} + \mu_i + \varepsilon_{it} \qquad (1)$$

D_{it} is define as crop diversity index. Here we consider cereal crops diversity index and tuber crops diversity index. Climate variables are: annual average temperature and annual average precipitation. We used two variables to measure international trade of agricultural products: Agricultural export trade share and agricultural import trade share.[3] The vector X_{it} represents others variables included in the regression such as: agricultural conventional inputs, population change, Agriculture Research effort in and others. α, β, γ and λ represent the respective vector parameters to be estimated. μ_i is an unobserved country fixed effect assumed to be correlated to observable covariates and ε_{it} a normally distributed random error term $u_{ij} \sim n(0, \sigma_u^2)$.

The econometrics model to be estimated is:

$$\begin{aligned} \boldsymbol{Crop\ diversity_{it}} = {} & \alpha\ Crop\ diversity_{it-1} + \beta_1\ Temp\ mean_{\ it} + \beta_2\ Precip\ mean_{it} \\ & + \gamma\ Trade_{it} + \lambda_1\ Agricultural\ land_{\ it} + \lambda_2\ Agricultural\ labor_{it} \\ & + \lambda_3\ Fertilizers_{it} + \lambda_4\ Irrigation_{it} + \lambda_5\ Population\ density_{it} \\ & + \lambda_6 Agricultural\ RD_{it} + \mu_i + \varepsilon_{it} \qquad (2) \end{aligned}$$

In order to capture the effect of climate (high or low values of temperature and precipitation) on crop diversity, we include the quadratic formulation in climate variable as in the ricardian model (Mendelsohn et al. 1994; Dinar et al. 1998). The model to be estimated becomes:

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[3] The indirect and direct effects of trade on biodiversity will largely be determined by the types of trade policies that countries adopt, and the relationship of these trade policies to other macro-economic factors, such as national debt, that can accentuate certain trading patterns and relationships. Trade policies affect trade flow (export and import) Conway (1998)

$$\boldsymbol{Crop\ diversity_{it}} = \alpha\ Crop\ diversity_{it-1} + \beta_1\ Temp\ mean_{\ it} + \beta_{11} Temp\ mean_{it}^2 + \beta_2\ Precip\ mean_{it} + \beta_{21} Precip_{it}^2\ + \gamma\ Trade_{it} + \lambda_1\ Agricultural\ land_{\ it} + \lambda_2\ Agricultural\ labor_{it} + \lambda_3\ Fertilizers_{it} + \lambda_4\ Irrigation_{it} + \lambda_5\ Population\ density_{it} + \lambda_6 Agricultural\ RD_{it} + \mu_i + \varepsilon_{it} \quad (3)$$

4.2. Discussion of variable used in the model

The dependent variable of the study is crop diversity focused on cereal crops and root and tuber. In literature, crop diversity is measured by various index, the best know are Shannon index and margalef index. The Shannon diversity index (H)[4], which was adapted from the information theory literature for use in ecology and agronomy, is a way to combine a number of qualitative or quantitative traits into a single index (Magurran, 1988). It measure both richness and relative abundance. The Margalef index measure the richness or the number of species or varieties encountered. In the case of our study, the construction of agricultural biodiversity is focused on cereal and tuber crops. Cereal crops are composed of *fonio, maize, millet, rice paddy, sorghum* and Tuber crops are composed of *cassava, sweet potatoes, taro, yams*. The description of the two indexes is in the table below:

Table 1: *Construction and explanation of agricultural biodiversity index*

Index	Concept	Construction	Explanation
Shannon	Evenness or equitability (Both richness and relative abundance)	$H = -\sum \alpha_i ln\alpha_i$ $H \geq 0$	αi = area share occupied by ith cereal crop or crop variety in country
Margalef	Richness	$M = (S-1)/lnA_i$ $M \geq 0$	Ai = total area planted to the ith cereal crop or crop variety by country , S is the number of varieties or the number of crops

[4] H is well known from statistics and information theory as the Shannon-Wiener expression for entropy (Shannon 1948; Wiener 1961).

In the case of our study, we use Shannon index because, it take account of both richness and relative abundance. High values of H would be representative of more diverse crops. A community with only one crop cultivated would have an H value of 0 because P_i would equal 1 and be multiplied by ln P_i which would equal zero. If the area share occupied by each crop is evenly distributed then the H value would be high. So, in general the H value allows us to know not only the number of species but how the abundance of the species is distributed among all the species in the community.

Explanatory variables

Climate change refers to a statistically significant variation in either the mean of climate or in its variability, persisting for an extended period (typically decades or longer). The variables commonly used the studies focused on climate change in agriculture are surface variables such as annual average temperature measured in degree Celsius (°C) and annual average precipitation in millimeter (mm), (Mendelsohn et al. 1994; Dinar et al. 1998, Adams et al. 1998a, 1998b; Darwin 1999; Dinar, A., Mendelsohn, R., Hassan, R. & Benhin, J., 2008).

International trade focused principally on agricultural products can be represented by agricultural export share and agricultural import share. Africa countries are specialized in the production of agricultural raw material and products. Trade policies in these countries consist in fostering agricultural to access international market; hence increase the international trade flow.

Population density is midyear population divided by land area in square kilometers.

Agricultural research effort is the annual monetary support given by the government to agricultural producers either for the production or specific agriculture products; in more general form such as infrastructure and research.

The rest of the data represented by agricultural inputs: *Agricultural land* refers to the share of land area that is arable, under permanent crops, and under permanent pastures. *Fertilizers consumption* (100 grams per hectare of arable land) measures the quantity of plant nutrients used per unit of arable land. Fertilizer products cover nitrogenous, potash, and phosphate fertilizers (including ground rock phosphate). *Agricultural labor* is measured as the total economically active agricultural population. *Irrigation* defined as the total areas equipped for irrigation.

4.3. Estimation techniques

Information from 8 countries has been collected for 39 periods (1970-2008), the starting and ending period are the same for all counties; hence the data is a balanced panel.
Dynamic panel model are characterized by the presence of one or more lagged endogenous variables among the regressors. The estimation of model (1) with standard econometrics methods (OLS and / or fixed effects model) gives biased and inconsistent estimators convergent because of the correlation between the lagged endogenous variable and individual heterogeneity. The introduction of the lagged dependent variable raises the particular issue of simultaneity between this variable and the residual error. Thus, it is possible to identify four potential sources of bias related to the model specification (1): simultaneity bias, reverse causality (independent variables potentially endogenous), temporal correlation of errors and omitted variables or errors measurement of the explanatory variables.

To overcome of these econometrics difficulties, the generalized moment method is used in dynamic panel data. There is two estimators: (a) Arrelano Bond estimator (1991) or GMM and System-GMM estimator developed by Blundell and Bond (1998). In the first GMM estimator, the strategy to solve the bias of omitted variables related to individual specific effect is based on the first difference transformation of equation (1):

$$\Delta D_{it} = \alpha \Delta D_{i\,t-1} + \beta \Delta climate_{it} + \gamma \Delta trade_{it} + \sum_j \lambda_j \Delta X_{jt} + \Delta \varepsilon_{it} \qquad (4)$$

Where Δ is the first difference operator. The first-difference transformation in (4) eliminates the individual effects (Baltagi, 2001) and reduces serial correlation. Equation (4) provides a basis for estimating the parameters in (1). When some of the explanatory variables are endogenous, a generalized method of moments (GMM) estimator can generate consistent parameter estimates. When the error terms ε_{it} are serially uncorrelated, valid instruments in the estimation of the first-difference model (4) include lagged values of the dependent variable (see Arellano and Bond, 1991). And given an appropriate choice of the instruments and weights, GMM can provide asymptotically efficient parameter estimates. Ahn & Schmidt (1995), and Blundell & Bond (1998) explored how using the initial conditions in levels, in addition to (4), can generate efficiency gains. This involves using a system GMM estimator that uses lagged differences as instruments for equations in levels, in addition to lagged dependent variables as instruments for equations in first-difference. Both the usual GMM estimator of (4) and the system GMM estimator were used in the empirical analysis.

Finally, two tests are associated with the GMM estimator in dynamic panel. The first is the over-identification test of Sargan / Hansen tests the validity of lagged variables as instruments. The second is the autocorrelation test of Arellano & Bond (1991) where the null hypothesis is no autocorrelation of second order errors.

4.4. Data sources

Our study use panel data over the period 1970-2008 covering 8 countries in West Africa: Benin Burkina Faso, Ivory Coast, Mali, Niger, Ghana Senegal and Togo. The data set is constructed from several data sources:

We use five cereal crops as (fonio, maize, millet, rice paddy, sorghum) and four tuber crops as (cassava, sweet potatoes, taro, yams) to construct agricultural crop biodiversity from cultivated areas and amount produced of each crop. The data used from FAO database is available to 1960-2010. Temperature and precipitation data from two sources. Annual average temperature and annual average precipitation is available over the period 1960-2006 for 5 countries (Benin, Ghana, Mali, Senegal and Togo) from CRU Database and GPCC database. Temperature and precipitation data for (Burkina Faso, Cote d'Ivoire and Niger) is created by the Tyndall Centre Mitchell, T.D. et al 2003. The data is available over period 1901-2000 and is based on the CRU TS 2.0 gridded data-set. Agricultural share export and agricultural share import are calculated from data collected from FAO database on the period 10970-2008. Agricultural share export (or import) represents respectively the part of agricultural export (or import) in total merchandise export (or import). The others variables include in the study from WDI indicators, UNCTAD, Agricultural Science and Technology Indicators database (ASTI) and FAO.

4.5. Summary statistics

Descriptive statistics for variables included in the analysis are reported in Table 2. The data cover information from several sources on 8 West Africa countries on 39 periods, hence 312 observations. The dependent variable (Crop diversity) represented by Shannon index is defined as the level of crop diversity focused on the major cereal crops (fonio, maize, millet, rice paddy, sorghum) and tuber crops (cassava, sweet potatoes, taro, yams) cultivated in the region. The results show that the mean value of Shannon diversity index is respectively 0.42

for cereal crops and 0.38 for tuber crops. The Shannon diversity index varies from 0.13 to 0.59 for cereal crops and from 0.03 to 0.69 for tuber crops.

Climate variables represented by temperature and precipitation. The temperature and precipitation data used in annual data calculated from 12 months of the year and show change and mean value. The mean of annual average temperature in the countries is 27°C. The annual mean temperature in this region varies from 25°C to 29°C (-2°C, +2°C). Also, we can see that the minimum and maximum average temperatures are respectively 25°C with extreme values (-7°C, +3°C) and 29 with extreme values (-3°C, +6°C). In the same analysis we observe that the mean value of annual mean precipitation is 69 mm and varies from 5.3 mm in dry season to 124 mm in rainy season.

Trade variable is defined by agricultural export share and agricultural import share. The result shows that in these countries of West Africa region, the part of agricultural products export represents in mean 50 percent of total export. The maximum value of agricultural export share was nearing 100 percent. In some countries export only is composed by agricultural product. Also the part of agricultural product import is in mean 23 percent of total import. The maximum value is 0.69 and indicates that some countries import more food product.

The statistics results indicate a high disparity in agricultural land, fertilizers-use and irrigation. In some countries include in the study we observe a great availability of agricultural land, a large amount of fertilizers-use and a large area of agricultural irrigation system equipped than others, where agricultural areas are small, low utilization of fertilizer and low system irrigation.

Table 2: Summary statistics

Variables	Obs	Mean	Std. Dev	Min	Max
Shannon index (cereal)	312	0.42	0.09	0.23	0.59
Shannon index (tuber)	312	0.38	0.13	0.03	0.67
Temperature mean in °C	278	27.1	0.77	25.6	29.2
Temperature max in °C	278	28.6	1.74	25.7	32.6
Temperature min in °C	278	25.2	2.2	18	27.7
Precipitation mean (mm)	278	68.9	33	5.3	124.1
Precipitation max (mm)	278	72.4	33.7	8.4	130.1
Precipitation min (mm)	278	65.3	32.3	3.4	117.2
Agricultural export share	312	0.50	0.25	0.05	0.99
Agricultural import share	312	0.23	0.09	0.03	0.69
Agricultural land *(million Hectares)*	312	155.24	120.65	17.2	437.82
Agricultural labor (million)	232	2.5	1.2	0.7	6.3
Fertilizers *(million Kg)*	309	21.3	22	0	170.3
Irrigation *(Total area 1000 Hectares)*	312	42.8	46.67	1	236
Population density *(people by Km^2)*	312	37.9	25.1	3.4	106.2
Agricultural RE *(million 2005 PPP$)*	196	28.8	18.4	2.6	94.6

5. RESULTS AND DISCUSSION

This section presents the econometrics results of the study. GMM and System-GMM are used. The study analyzes the impact of climate change and international trade of agricultural products on crop diversity. The results are reported in table 3 and table 4. In each table we present the results of four specifications: (1) control for climate variables, (2) control for climate and trade variable, (3) all variables in the model with one-step GMM and (4) all variable in the model with one-step system-GMM.

In the Arellano-Bond approach, the error term ε_{it} is assumed to be serially uncorrelated. This is essential to generate the consistency of the parameter estimates. If ε_{it} is not serially correlated, there should be no evidence of second-order serial correlation in $\Delta\varepsilon_{it}$. Using the standardized average residual autocorrelation and following Arellano & Bond (1991), we tested whether $\Delta\varepsilon_{it}$ exhibited second-order serial correlation. The Arellano-Bond test statistic of second-order serial correlation in each specification cannot reject the null hypothesis. This indicates that the assumption that the ε_{it} are serially uncorrelated appears supported by the data. Next, we implemented a Sargan/Hansen test of the overidentifying restrictions. The hypothesis being tested with the Sargan/Hansen test is that the instrumental variables are uncorrelated with the residuals, a key assumption to support the consistency of the GMM estimator. The null hypothesis is not rejected. Thus, from the Sargan/Hansen test results, the instruments pass the test: they appear to satisfy the orthogonality conditions required by GMM. However the System-GMM approach gives a more significant variables than GMM approach when taking account of the entire explanatory variable in the model.

In each specification the lagged explanatory variable are found to be positive and statistically significant. This stresses the importance role of dynamics. The results show climate variables (Temperature and precipitation) have significant impact on crop diversity. Temperature has negative impact on crop diversity (cereal as tuber crops) in the most of specification and positive impact with annual mean temperature squared. We see U-shaped relationship between temperature and crop diversity. However we see the Hill-Shaped relationship between precipitations with crop diversity. We note that crop diversity increases with annual mean precipitation, attains a maximum value and decreases.

We see that agricultural trade export and import have negative impact on cereal crop diversity. This result could be explained by the fact that agricultural products for export are essentially annuity products not intended for final consumption. These crops occupy more cultivated areas than crops for food consumption and trade policies are more incentive for the exports of intermediate goods. This is the case of cocoa in Cote d'Ivoire and Ghana, groundnuts in Senegal, cotton in Benin, Burkina Faso. The negative impact of agricultural import share could be explained by the fact that in these countries, rice is the major cereal product consumed and most widely imported. Therefore the production of many cereal crops in these countries relatively remains low.

When we consider the impact of trade variables on tuber crop diversity. The results show that agricultural export share has negative impact on tuber crops diversity and agricultural import share has positive impact on tuber crop diversity.

The results of specification (3) and (4) in each regression show that agricultural labor, fertilizers and irrigation have positive and significant impact on crop diversity. However population density has negative and significant impact on crops diversity. These results have been found in several works studies analyzing the determinant factors in agriculture production.

Table3: *Estimates of cereal crops diversity regression (GMM and System- GMM approaches)*

Variables	**Cereal crop diversity**			
	GMM Only climate variable	GMM Climate and trade variables	GMM All variable in the model	SYST-GMM All variables in the model
$Crop\ diversity_{t-1}$	0.5592***	0.4020***	0.5626***	0.3003*
	(4.37)	(5.27)	(5.84)	(1.73)
Temp mean	-0.1904	-0.2525**	-0.7073	0.0021
	(-1.56)	(-2.52)	(-0.45)	(0.01)
Temp mean squared	0.0035	0.0046**	0.0013	0.00008
	(1.57)	(2.47)	(0.46)	(0.02)
Precip mean	0.0015*	0.0015**	0.0007	0.0037***
	(1.94)	(2.17)	(1.04)	(4.58)
Precip mean squared	- $7.18.10^{6}$*	- $8.01.10^{6}$**	- $2.31.10^{-6}$	$-1.6.10^{-5}$***
	(-1.79)	(-1.96)	(-0.62)	(-3.45)
Agricultural export share		-0.0086	-0.0089	0.0722***
		(-0.39)	(-0.89)	(4.11)
Agricultural import share		0.0361*	-0.0461	-0.2986**
		(1.71)	(-1.48)	(-2.04)
Agricultural land			-0.00003	$6.6.10^{-6}$
			(-1.49)	(0.54)
Agricultural labor			0.0186**	0.0283**
			(2.38)	(3.30)
Fertilizers			0.0002	0.0002***
			(3.28)**	(3.92)
Irrigation			0.0001	0.0004**
			(1.13)	(2.32)
Population density			-0.0012**	-0.0014***
			(-2.94)	(-4.79)
Agricultural RE			-0.0002**	0.00005
			(-2.70)	(0.14)
Debt			$2.7.10^{-7}$	$-9.2.10^{-6}$**
			(0.25)	(-2.44)
Arellano-Bond AR(2)	0.700	0.578	0.105	0.133
Overid. Restrictions				
Sargan test	0.759	0.301	0.761	0.271
Hansen test	1.000	--------	1.000	1.000

Table 4: *Estimates of tuber crops diversity regression (GMM and System- GMM approaches)*

Variables	**Tuber crops diversity**			
	GMM Only climate variable	GMM Climate and trade variables	GMM All variable in the model	SYST-GMM All variables in the model
$Crop\ diversity_{t-1}$	0.7379***	0.7760***	0.5580***	0.6276***
	(6.45)	(7.39)	(9.40)	(8.82)
Temp mean	-0.5572*	-0.4833*	-0.0687	-0.4346**
	(-1.91)	(-1.65)	(-0.24)	(-2.01)
Temp mean squared	0.0104*	0.0090*	0.0013	0.0083**
	(1.94)	(1.67)	(0.26)	(2.15)
Precip mean	0.0004	0.0001	-0.0015	0.0035*
	(1.11)	(0.29)	(-1.25)	(1.71)
Precip mean squared	$3.7.10^{-7}$	$2.9.10^{-6}$	$7.92.10^{-6}$	-0.00001
	(0.14)	(0.95)	(1.13)	(-1.13)
Agricultural export share		0.0352	-0.0105	-0.0073
		(1.08)	(-0.54)	(-0.11)
Agricultural import share		0.0947	-0.0346	0.0651
		(1.39)	(-0.69)	(0.75)
Agricultural land			0.00005*	0.00002**
			(1.88)	(2.21)
Agricultural labor			-0.0080	0.0044
			(-0.73)	(0.65)
Fertilizers			-0.0003**	0.0001
			(-1.99)	(0.55)
Irrigation			0.00007	-0.0002
			(0.57)	(-1.01)
Population density			-0.0001	-0.0004
			(-0.25)	(-0.41)
Agricultural RE			-0.0001	0.0012*
			(-0.39)	(1.71)
Debt			$-2.6.10^{-6}$	0.00001
			(-0.99)	(-1.38)
Arellano-Bond AR(2)	0.309	0.325	0.413	0.714
Overid. Restrictions				
Sargan test	0.071	0.410	0.191	0.999
Hansen test	------		-----	1.000

6. CONCLUSION AND RECOMMENDATION

In this paper, we examine the effect of climate change and international trade on crop biodiversity using dynamic panel data on 8 West African countries spanning the period 1970 to 2008. First, in all specification we find evidence that climate change has effect on crop diversity and has significant impact. However in most of specification the international trade represented by agricultural export share and agricultural import share has negative impact on crop diversity and the impact is not significant. This result corroborates the assertion of complex understand of relationship between trade and agricultural biodiversity. Second, the study finds evidence that fertilizers use and irrigation are important factors for the conservation of crop diversity and finally the study show that population growth is considered as threat of crop diversity. When the population increases, the number of inhabitant by kilometers squared increases, urbanization is increasing and crop for food becomes insufficient.

The results of our empirical analyses have serious implications for agricultural and environment development policy. The use and conservation of agricultural biodiversity is the central means in assuring adaptation of humanity to climate change challenges international trade and to provide global food security. Also increasing or even maintaining global food production is not possible without agricultural biodiversity. First, good management and the conservation of agricultural biodiversity can be an effective strategy to adapt agriculture to climate. A mix of different crops and varieties in one field is a proven and highly reliable farming method to increase resilience to erratic weather changes. Second, the governments must support and encourage the production of local products that are directly used in consumption with the aim to reduce agricultural food import. That is the case of rice and others cereal crop. Finally the government must invest in irrigation and increasing participation of research institutes, policy makers and private sectors integrating agricultural biodiversity research and use in national plans.

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