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Revisiting Estimation of Agricultural Production Function for Sustainable Agricultural Policies in Sub-Saharan Africa (SSA): Evidence from Togo.

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Abstract: In Sub-Saharan Africa, the bulk of agricultural output is produced by small holder farmers who continue to depend on rainfall. As such, agricultural economists often use average rainfall as a summative environmental indicator in estimating agricultural production function. This methodology is flawed. A close scrutiny of agricultural practices /agronomic sciences reveals that agricultural output is more determined by rainfall distribution than average rainfall. This relationship is explored in the Togolese context. The conclusion reached is that, between 1965 and 1992, intra-annual rainfall distribution measured by its standard of deviation has not been relevant in explaining the variation of food production in Togo due to the continuous degradation of the ecosystems. This result provides additional information for improved decision making and calls for urgent account of environmental aspects in the formulation of sustainable agricultural policies in SSA

Introduction

The importance of agriculture in sub-Saharan Africa (SSA) cannot be stressed enough given that it is central to economic growth and most of economic activities in the region is still dependent on agricultural expansion. In most of Africa, about 80 % of people work in agriculture. It is the main economic sector generating, in most countries, 30 to 60 % of Gross Domestic Product (GDP), or even more if valued properly by national accounts. In the year 2000, agricultural value added as a share of GDP was 17 percent whereas service and manufacturing sector account for 53 and 14 percent respectively.
The crux of the matter is that, in Africa, the bulk of agricultural output is still produced by smallholder farmers who unfortunately continue to depend on rainfall.
Average annual rainfall across Africa is sufficient to grow a wide range of crops. However, rainfall varies widely within growing seasons and from year to year in most of African countries, leading to serious dry spells during crop development and often years with inadequate rain and droughts. Also, there is space variability. Well-watered areas amount to only about a quarter of total area. Elsewhere, rains are inadequate in volume and highly variable in timing.
Since the drought of the early 1970s, there has been extensive discussion as to whether this indicates long term changes in the climate with ensuing changes in the ecology and the advance of the desert. Present evidence provides inconclusive support for the hypothesis of secular trend in climatic conditions. Instead, there are indications that in some locations the natural population has been degraded through overgrazing, and that expansion of cleared land areas has negatively influenced evaporation and rainfall. But these were the result of acts of man-a relative overpopulation and overgrazing in semi-arid areas under the pressure of human and animal population increases-and not of autonomous changes of climate.
The situation is not different in Togo: agriculture employs about 67.4% of the working population and to contributes to about 41.2% of GDP, which is produced by small holder farmers.
Whatever the evidence, agriculture in Africa in general and in Togo in particular will unfortunately continue to depend on rainfall given the accelerated degradation of the ecosystem. Thus, the latter will play in the future an important role in the explanation of agricultural production in sub-Saharan Africa. Africa is therefore caught up in a vicious circle: destruction of the environment by man with its attended distortion of the hydrological cycle; poor agricultural performance and further degradation of the environment.
However, a close scrutiny of agricultural economics literature in the past fifty years reveals that most of estimation of production functions has been based on neo-classical growth models that emphasized **physical and human capital** accumulation. These models have shown their limits in front of the

environmental issues. In fact, as production is itself dependent on natural resources, the physical and labour productivity decreases with the exhaustion of natural resources (Gillis et al., 1998). The consideration of **natural capital** refocuses the theoretical debate on sustainable development (WCED, 1987; Colby, 1989;Batie, 1991;CCE, 1992;Piriou, 1997) Thus, the **natural capital** must be considered in the explanation of agricultural production just like the physical and human capital in sub-Saharan Africa.

1. State of Art

Though it is recognized that environmental factors play an important role in determining agricultural productivity, only few agricultural economists have investigated the role of these factors. To prove the above, about 227 articles of Agricultural Economists in the Journal of the International Association of Agricultural Economists between 1991 and 2003 were consulted. Of these publications, only 30 publications (13%) dealt with environment issues in general and 14 publications (6%) with water issues. This implies that about 81% of publications were devoted to non environmental issues in the fields. More surprisingly, 6 of the total number of publications (< 3%) concern Africa, and only 4 of these publications have been published by Africans. The following table 1 depicts the situation.

Table 1: Status of series/publications of Agricultural Economics consulted between 1991and 2003

Environment Issues		Non environment & Water	Geographical coverage		Nationality of authors		Total publications Consulted
Water	Water & environment		African	Non African	African	Non African	
14	30	197	6 (<3%)	24 (11%)	4	26	227

Source: Author's calculation

The crux of the matter is that not only environmental issues and for that matter water issues have not being investigated by African agricultural economists in SSA.

Moreover, out of the 227 publications, only one article has attempted to model agricultural production of small-scale farmers in sub-Saharan Africa using environmental factor. The article, based on cross-sectional data, used land fertility level as the only environmental variable as land quality can vary within a relatively small geographical area as compared with other agro-ecological factors. The coincidence is that the case study is derived from western Kenya. (Odulaja and Kirios, 1996).

In few cases where environment factors (climatic conditions) are investigated, agricultural economists use either ordinal scales (good/bad;high/average/weak) or average rainfall as a summative environmental indicator in estimating agricultural production function. (Odulaja and Kiros, 1996; Frisvold and Ingram, 1995). Thus, the literature relating production to environmental factors is very scanty in SSA.

The present study built on these assets and focused on the measuring of rainfall as a crucial environmental factor. The methodology proposed is an attempt to improve the measurement of rainfall in the estimation of agricultural production function based on time series data in SSA. Instead of using the mean of rainfall as environmental index, it utilizes its standard of deviation. A close scrutiny of agricultural practices /agronomic sciences reveals that agricultural output is more determined by rainfall distribution than rainfall's mean. This relationship is explored in the Togolese context.
The main hypothesis is that the growth of the agricultural sector is less associated with the mean of rainfall than rainfall distribution in the explanation of agricultural performance and that environment factors compared with than investments in physical and human capital are not significant in explaining agricultural growth in SSA.

2. Setting: the Production-Environment in Togo

In Togo, the state of the natural environment continues to suffer from physical degradation. In fact, 90% of cultivated lands have been degraded leading to the fall of agricultural productivity; the forest resources that cover 1 396 200 ha have been depleted at 15 000 ha a year whereas the rate of reforestation is only 1000 ha per year since 1993; the protected forests representing about 14% of present country cover in 1990 has been occupied by the local communities at a rate of 30 to 100% since the socio-political crises of the country between 1991-1993. All these put high pressures on the natural resources of the country.

At the same time, the rate of population growth that is of 3.2% per year is higher than food production growth rate that is 2.7% per year. This situation is not that different from that observed in SSA.

In order to reduce the rate of environmental degradation, the current environment policy focuses on the following:

- the integration of environment concerns in national development plans;
- the reduction or the elimination of negative environment impacts of public and private development projects;
- the strengthening of national capacities in the management of natural resources.

In the light of the above, the agricultural policy has been oriented towards:

- promoting a sustainable agricultural development in order to ensure sustainable food security;
- improving conservation, manufacturing and distribution/marketing of agricultural products;
- supporting the development of integrated agricultural projects that prevent natural resources degradation;
- promoting technologies that safeguard sustainable exploitation of fragile ecosystems;
- developing cultural practices that prevent natural resources degradation and reduce the negative impacts of industrial crops development;
- developing water mobilization for agriculture, livestock, fishery and for off-seasons cropping (MEPF, 1998).

Nevertheless, it is important to mention that most of the above strategies have not been implemented as expected.

3. Model Specification and Data Sources

3.1. The conceptual framework

In order to evaluate the impact of environment factors on food production in Togo, a neoclassical production function proposed by Solow and Swan forms the theoretical framework of most empirical studies (Feebairn, 1994; Frisvold and Ingram, 1995).

The simple representation of the model is:

$$\mathbf{Y = f(K, L, T)} \quad \ldots\ldots(1)$$

where, Y = physical product , K = capital, L = labour

T = all the other factors including technology and environment factors

An improved and adapted specification of production in sub-Saharan Africa will draw from the works of Odulaja and Kirios (1996) in a case study in Western Kenya. For these authors, the list of factors responsible for the low agricultural production by farmers in sub-Saharan Africa may not be exhaustible and categorization of these factors may not also be generalized. Ssennyonga (1989) and Kirios (1993) classified the various factors explaining agricultural production by small farmers in SSA into six groups: (1) endowments of basic factors of production, (2) agro-ecological factors; (3) access to modern know how and production inputs; (4) ownership of livestock; (5) structure and diversity of production activities; (6) gender-related and other personal characteristics. Odulaja and Kirios (1996) added a seventh factor (7) institutional arrangements

They then defined the small-scale sub-Saharan Africa production function (Y) as a function of land (or herd size), L, environment effect, E, and management effect, M represented as

$$\mathbf{Y = f(L)g(E)h(M)} \quad \ldots\ldots(2)$$

where f, g, h are functions relating L, E, and M, respectively to Y.

The generalized model was written as:

$Y=aL^b\exp(cE+dM)+\varepsilon$ ……………………………………………………………………………………………(3)

where a, b, c and d are positive constants and ε the residual

Environment (E) includes factors such as rainfall, soil type, humidity, temperature, erosion and vegetation. As these factors are location specific, they are often represented in most socio-economic surveys as good, bad, high, medium, low etc (Lomperis, 1991; Yanaihara, 1993; Flaherty and Jenglalern, 1995.). For more meaningful modeling, the above approach transforms the above scales to continuous scales using the uniform ranking transform method. The **mean** of the uniform-ranks over all the environmental variables is then obtained for each sample to represent the environment index. Hence the environmental index, E, is distributed in the interval [0,1].

In time series studies, the situation is different and such environmental parameters such as rainfall, temperature, soil fertility (N,PK) may be quantified and the **mean** of these environmental indices may be calculated.

The present study improves the measuring of rainfall in agricultural production function estimation by the introduction of the standard deviation of rainfall instead of the mean as a proxy of rainfall distribution due to agronomic practices or agricultural requirements.

The methodology is the following:

1. The first step is to gather a comprehensive daily rainfall data of raining seasons in the country over many years;
2. The second step is to calculate the mean of daily rainfall of a given year;

The mathematical computation of the mean of this rainfall in a given year in a country is as follows:

Suppose in a given country, there are r agro-ecological zones Z_i, with i = 1,….,r ; S_{ij} seasons in given zone j= 1,……ki ,it may be demonstrated that

The mean of daily rainfall of r zones in a given growing year in a given country is:

$$\overline{m} = \sum_{i=1}^{r} \frac{m_i}{r}$$ where m_i is the mean of all the zones Z_i , i = 1,…,r,

but $$m_i = \sum_{j=1}^{k} \frac{m_{ij}}{k_i}$$ where m_i is the mean of the given season S_j^i (k_i seasons) in the zone Z_i

with $$m_{ij} = \frac{\sum_{l=1}^{n_{ij}} R_l^{ij}}{\left|S_j^i\right|}$$ where n_{ij} the total number of rainfall during the season S_j^i in the zone Z and $\left|S_j^i\right|$ is the total length of the season S_j^i expressed in number of days.

By replacing the above expressions in the equation, it follows that the mean of rainfall in the country during a growing year is:

$$\overline{m} = \sum_{i=1}^{r} \frac{\sum_{j=1}^{k_i} \frac{m_{ij}}{k_i}}{r} = \sum_{i=1}^{r} \frac{1}{r}\left(\sum_{j=1}^{k_i} \frac{1}{k_i} \frac{\sum_{l=1}^{n_{ij}} R_l^{ij}}{\left|S_j^i\right|} \right)$$

$$= \sum_{i=1}^{r} \frac{1}{r} \sum_{j=1}^{k_i} \frac{1}{k_i \left|S_j^i\right|} \sum_{l=1}^{n_{ij}} R_l^{ij}$$

$$\overline{m} = \sum_{i=1}^{r} \sum_{j=1}^{k_i} \sum_{l=1}^{n_{ij}} \frac{R_l^{ij}}{r k_i \left|S_j^i\right|}$$

3. The third step is to calculate the intra-annual variation of the rainfall within a given year represented by the standard deviation of rainfall as follows:

The mean of variance of daily rainfall (V_i) of r zones Z_i in a given growing year in a given country is:

$$v = \sum_{i=1}^{r} \frac{V_i}{r}$$ with $Z_i = Z_1$ Z_2, ……. Z_r and given V_i = V1,V2 …..Vr

The variance of daily rainfall (V_i) in the zone Z_i r is computed as follows:

Given k_i seasons in the zone Z_i, if v_j^i is the variance of rainfall computed over one season S_j^i in the zone Z_i, then: $$V_i = \sum_{j=1}^{ki} \frac{V_{ij}}{k_i}$$

Vi is therefore the mean of rainfall variances of k_i seasons S_1^i , S_2^i , …. S_k^i in the zone Z_i.

To compute v_j^i (variance of rainfall over the season S_j^i of the zone Z_i).

Let us consider m_{ij} as the rainfall mean computed over the season v_j^i .

With n_{ij} , $\left|S_j^i\right|$, R_l^{ij} , the total number of rainfall days of the season S_j^i , the length of the season in days S_j^i and the rainfall quantity of rainfall of the l-th day during the season S_j^i

$$V_j^i = \sum_{l=1}^{n_{ij}} \frac{(R_l^{ij} - m_{ij})^2}{\left|S_j^i\right|}$$ Or $$m_{ij} = \sum_{q=1}^{n_{ij}} \frac{R_q^{ij}}{\left|S_j^i\right|}$$

It follows that:

$$V_j^i = \sum_{l=1}^{n_{ij}} \frac{\left(R_l^{ij} - \sum_{q=1}^{n_{ij}} \frac{R_q^{ij}}{\left|S_j^i\right|}\right)^2}{\left|S_j^i\right|}$$

It can be demonstrated that:

$$V_j^i = \frac{1}{\left|S_j^i\right|^3} \sum_{l=1}^{nij} \left(R_l^{ij} \cdot \left|S_j^i\right| - \sum_{q=1}^{nij} R_q^{ij}\right)^2$$

Thus :

$$v = \sum_{l=1}^{r} \frac{1}{r} \sum_{j=1}^{k_i} \frac{1}{k_i} \cdot \frac{1}{\left|S_j^i\right|^3} \sum_{l=1}^{n_{ij}} \left(R_l^{ij} \cdot \left|S_j^i\right| - \sum_{q=1}^{n_{ij}} R_q^{ij}\right)^2$$

$$v = \frac{1}{r} \sum_{i=1}^{r} \sum_{j=1}^{k_i} \sum_{l=1}^{n_{ij}} \frac{\left(R_l^{ij} \cdot \left|s_j^i\right| - \sum_{q=1}^{n_{ij}} R_q^{ij}\right)^2}{k_i \cdot \left|s_j^i\right|^3}$$

The standard deviation of rainfall as the index of rainfall variability in a given growing year in a given country is: $IDPLU = \sqrt{v}$

3.2. Empirical model

For the present study the theoretical formulation of the food production is a function of three sets of variables: **physical capital (**K_p**,), human capital** (K_h) **and environmental capital (**K_E) as follows:

$Y_t = f(K_p, K_h, K_E, \varepsilon_h)$……………………………………………………………………..(4)

The empirical model is expressed as follows:

$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 H + \beta_5 SAN + \beta_6 NUT + IDPLU + \varepsilon$……………...(5)

where,

Y = food production index per capita (%);

H = the literacy rate index for people more than 15 years old (%), it is used as proxy as this latter is not available for the agricultural sector; (%)

X_1 = index of cultivated area in km² per capita (%);

X_2 = index of irrigated agricultural area in % of the total of agricultural areas – It represents the level of investment in rural infrastructures;

X_3 = quantity of fertilizers index per acres (%); it is a proxy of the level of agricultural technology;

SAN = index of health expenditures share in total national budget;

NUT = index of food availability per capita in kilocalories, a proxy of the nutritional status;

IDPLU= index of the rainfall variability; standard deviation (%)

ε, is the usual error term.

All the variables being expressed in natural logs, the coefficients obtained are elasticities

4. Data

4.1 Descriptive statistics

The data used in this study are from secondary sources. The data cover the period 1965-1992. First, the data on production and used for explanatory variables originate from the World Bank database published in 1998. The real income (IR) per capita is a ratio of the real GNP to the total population. Second, the data on food security and availability (NU) are obtained from FAO. The data on these variables are calculated periodically by FAO on the basis of a survey conducted at household levels. Since these surveys are not carried out every year, data were generated, assuming that the food security and availability indices do not change significantly from one survey to another. The data on the literacy rate come from the national reports on sustainable human development published regularly by UNDP.

Moreover, monthly rainfall data exist in Togo and were collected from the national Meteorology office. The availability of these disaggregated data enable the computation of intra-annual standard of deviation of the rainfall (IDPLU). Data on health indicator, SAN (share of health in national budget) come from Health Statistical Directory between 1965 and 1996.
All the data were calculated as indices (base 100 in 1987). The data processing and analysis were carried out using the econometric software EVIEWS.

The table 2 summarizes the descriptive statistics of variables used in the study. It shows that the variables X_3 and H has the highest variability with standard deviation of 1,57 and 0,53 respectively whereas the standard of deviation of human capital and rainfall variables from 0,06(H) to 0,39 (IDPLU).

Table 2: Statistics summary for dependent and independent variables

	Mean	Median	Maximum	Minimum	Standard deviation
X1	4,84	4,84	5,25	4,46	0,23
X_2	4,36	4,47	4,62	3,39	0,33
X_3	2,82	3,14	4,72	0,00	1,57
SAN	4,83	4,78	5,33	4,42	0,26
H	3,94	3,66	4,65	3,19	0,53
Y	4,77	4,77	4,98	4,58	0,13
NUT	4,62	4,63	4,75	4,56	0,06
IDPLU	4,36	4,31	5,09	3,59	0,39

Source: Author's calculation

4.2. Validity tests

4.2.1 Unit root tests

The unit root tests show that the hypothesis of non-stationarity is accepted in level for all variables with trend and constant. In the first difference form, the tests show that non-stationarity is rejected at level α = 5% for all variables included in the model (table 3).

Table 3: Results of unit root tests

Variables	**In Level**	**In 1st Difference**
SAN	-0,57 [4]	-3,98* [1]
H	-2,07 [4]	-3,64* [2]
X_2	-1,90 [1]	-3,82* [1]
X_3	-1,92 [4]	-4,00* [1]
NUT	-2,66 [2]	-2,55* [3]

Y	-2,16 [4]	-3,63* [3]
IDPLU	-2,17 [3]	-7,03* [1]
X_1	-2,44 [4]	-3,41* [3]

The values in brackets are the lags number introduced in the model. The sign (*) means that the hypothesis Ho of non-stationarity is rejected at level α=5%. The AIC statistics was used to determine the number of lags.

Source: Computation of the author

4.2.2 Cointegration tests

The unit roots tests (Dickey-Fuller) applied to residual show that food production (Y) is co-integrated with individual series H, X_1 et X_3 at $\alpha = 5\%$ which is not the case for SAN, NUT, IDPLU, X_2. series. However, in general all the independent variables series are co-integrated with Y at 5% level.

The results of the unit root (Table 3) and co-integration tests (Table 4) show that the long-term relations defined in the estimations are co-integrated. Thus the use of ordinary least squares estimations (OLS) are irrelevant (Engle and Granger, 1987). Instead error correction models (ECM) are therefore their best short-term specifications. The ECM of the long-term model is as follows:

$$\Delta Y_t = \theta_1 \Delta X_{1t} + \theta_2 \Delta X_{2t} + \theta_3 \Delta X_{3t} + \theta_4 \Delta H_t + \theta_5 \Delta SAN_t + \theta_6 \Delta NUT_t + \theta_p \Delta IDPLU\ (1-\lambda) ECM_{t-1} + v_t \quad \text{.......(5)}$$

The coefficient (1-λ) reflects the magnitude of the adjustment, which takes place in the short run in order to correct the instability of the past period.

Once the stationary properties of the series are established, the co-integrated relation of the series is tested (Johansen, 1988). This test allows to "normalize" the co-integration relation through a procedure based on the probability techniques. The co-integration techniques allow to verify the existence or not of a long-term equilibrium relation between the variables. The co-integrating relation constitutes the long-term model.

The ECM is the residual obtained through the estimation of the long-term model, represented by the equations (5). The coefficients θ, δ and π represent the short-term elasticity, while the Δ translates the fluctuations between two successive years. Due to the fact that all the variables of the three models are stationary, the error terms $v_{t,}$ μ_t, ω_t, are all distributed according to the normal centred reduced law.

The long-term model (5) was estimated by generalised least square (GLS) due to the presence of autocorrelations of errors. The introduction of Dum binary variables in the long-term models was made necessary due to the existence of a structural break in the two models estimations, from 1980 as shown by the Chow's test. The reasons for these breaks lie in the economic crisis experienced by the country at the beginning of the 80's. This crisis leads to the country economic setbacks and the implementation of structural adjustment programs (SAP). Moreover, Klein test did not disclose existing multicollinearity between the explanatory variables in the estimations.

The short term model (table 6) being estimated by ordinary least squares (OLS), some explanatory variables such as literacy, irrigated lands, use of fertilisers, health and nutrition index were lagged two years to assess the lagged effects of these investments.

Table 4: Results of cointegration tests or unit roots tests

Co-integration relationships	**ADF [lags]**
Y on X_1	-2,30* [4]
Y on H	-2,18* [3]
Y on X_2	-1,00 [3]
Y on X_3	-2,05* [3]
Y on SAN	-0.04 [5]
Y on NUT	-0,12 [3]
Y on IDPLU	-1,48 [1]
Y on H, X_1, X_2, X_3, NUT, SAN,IDPLU	-2,73* [3]

The values in brackets are the lags number introduced in the model.. The sign (*) means that the hypothesis Ho of non-stationarity is rejected at level α=5%. The AID statistics was used to determine the number of lags.

Source: Author's calculation

5. Environment as a Determinant of Food Production

5.1. The long run model

Statistically, the long run model is significant as shown by the (R^2) of about 98%.(Table 5)

First, the environment factor (IDPLU) is not significant and is negative which implies that food production has not benefited from rainfall distribution for the period 1965-1992.

Second, with respect to other variables, a distinction must be made between human capital variables and physical capital variables. First, for the human capital variables, the interactive effect of the economic crisis with literacy (H) reveal that literacy has not played any role in the explanation of food production. On the contrary, the health variable yields the expected result as its effect is not only positive but also significant as corroborated by the elasticity of SAN (0.06) and DUM. SAN (0.02). Second, the physical variables: (X1: cultivated area; X2: fertilizers use, X3: irrigate area) contribute significantly to the explanation of food production for the period 1965-1992.

Table 5: Estimation of long-term model

Variables	Dependent variable Y	
	Coef. (β)	T of Student
Constant	-6,73	-8,77*
X_1	0,96	13,88*
X_2	0,09	3,13*
X_3	0,06	6,63*
H	0,21	8,11*
SAN	0,06	2,10*
NUT	1,12	11,28*
IDPLU	-0,004	-0,35
Dum	1,55	3,93*
Dum × X_2	-0,38	-8,10*
Dum × H	-0,21	-8,07*
Dum × SAN	0,20	3,72*
	R^2 = 0,975 DW = 2,69	

** The sign (*) means that the coefficient is significant at 5% level*
Source: Author's calculation

5.2. The short run model

The short run model is also satisfactory and economically significant as shown by the R^2 and Fisher that are 70% and 7.99 at 1% level. The ECM found to be negative and significant which confirms that overall food production is co-integrated with the explanatory variables. (Table 6). The estimations yield the following results.

First, with respect to the environmental indicator, it is important to notice that the result corroborates that of long term i.e. is rainfall distribution has not induced favourable food production in Togo for the period 1965-1992.

Second, contrary to results obtained in the long term model, human capital such as literacy is negative and not significant due to the low level of investments (0.001% of the national budget and to the inadequacy of education benefited by the farmers leading to the likely flight from agriculture.

Though all the other human capital variables have the expected results, only nutrition is significant.

In conclusion, the results of short and long term models indicate that the environment variable (rainfall distribution) compared to other variables contributes less to the explanation of food production in Togo. In fact since almost four decades, rains are unforeseeable and display low distribution over space and time.

The main cause is among others the extensive agricultural and its attending deforestation and continuous degradation of the ecosystems.

Table 6: Estimation of short run model

Variables	Dependent Variable ΔY	
	Coef. (θ)	T Student
ΔX_1	0,72	2,51*
ΔX_2	0,02	0,22
ΔX_3	0,05	3,29*
ΔH	0,06	1,34
ΔSAN	0,06	1,46
ΔNUT	0,63	2,86*
$\Delta X_2(-2)$	-0,08	1,61
ΔIDPLU(-2)	-0,01	-1,42
ΔH(-2)	-0,18	-3,59*
ECM (-1)	-0,55	-2,76*
	R^2 = 0,70 F = 7,99 (0,0002) LM Test = 0,37 (0,70) White= 1,27(0,41)	

** * The sign (*) means that the coefficient is significant at 5% level*
Source: Author's calculation

Conclusion and Policy Implications.

First, agriculture in Africa in general and Togo in particular will unfortunately continue to depend on rainfall given the accelerated degradation of the ecosystem. However, very few African agricultural economists have devoted their research works on environment and for that matter water issues during the past ten years at international leve.

Second, in Togo, the short and long term estimations confirm that the growth of food production is less associated with climatic conditions (rainfall distribution) than with physical and human investments. Consequently the environment indicator (rainfall distribution) does not play a significant role in the explanation of the variation of food production in Togo.

Thus, African agricultural economists should play a more active important role, through their investigations, in bringing to the front the strong linkages between the food production and the degradation of the ecosystems in Africa. In doing so, they will provide appropriate information base that will not only create more awareness but also enable decision makers to formulate more informed sustainable agricultural policies in SSA. It is therefore recommended that environment issues continue to be top in the current and future research agenda in Africa. African agricultural economists must therefore seize the opportunity, through their research works, to participate more actively in meeting these challenges.

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