

**EXTENSIFICATION versus INTENSIFICATION:
REVISITING THE ROLE OF LAND IN AFRICAN AGRICULTURAL
GROWTH**

Guy Blaise NKAMLEU¹

October, 2011

C:\conference\AEC\AEC2011 Nkamleu full paper.doc

¹ African Development Bank; Tunis, b.nkamleu@afdb.org

EXTENSIFICATION versus INTENSIFICATION: REVISITING THE ROLE OF LAND IN AFRICAN AGRICULTURAL GROWTH

Abstract

The consensus in international economic development circles is that agricultural growth in Africa is the cornerstone of the MDGs goal of an annual growth rate above 7% a year required to achieve economic convergence with other developing countries and to maintain a similar quality of life. The agricultural growth can be achieved either by using more input – mainly land (extensification) and/or by improving productivity level.

The present paper revisits the extensification-intensification paradigm in the African agricultural context, and explores the ability of land use pattern and technological progress to keep up with population growth. Using macro panel data downloaded from FAOSTAT, the focus of the study is on investigating whether the production structure of the agricultural sector has changed during the last decades. In particular, the study sheds light on the state of land use in the agricultural sector, and estimates how much growth in output is associated with growth in land area and other physical capital, and how much growth is due to total factor productivity.

The study found that the African agricultural sector still follows an extensive and unsustainable production pathway. During the last decades, the contribution of factor inputs on agricultural production growth has been on average larger than the contribution of productivity growth. In relation to land resources, the results suggest that agricultural land expansion is increasing and the system is getting closer to the limit. Although declining, the contribution of land expansion on the production growth is still quite high. The study also highlights the extent to which land use pattern and agricultural growth contributors has varied over time. The paper ends by drawing implications for policy targeting in the context of the food crisis and the need for a more greening agriculture.

Key words: *Agricultural intensification, Growth accounting, Total factor productivity, Factor accumulation, Agricultural land, African agriculture.*

JEL classification: N50 ; O47 ; D24 ; Q15

Introduction

Growth in agriculture, particularly in Africa has been strongly tied to overall economic growth in the literature, given its importance in overall GDP, export earnings and employment, as well as its strong link to non-agricultural growth. The major challenge facing agriculture in many parts of sub-Saharan Africa is how to increase farm production to meet changing food needs without degrading the natural resource base. The agricultural sector can improve the level of production either by using more input – mainly land (extensification) and/or by improving technological level. All these put together determine both agricultural and economic growth in Africa. Historically, farmers were able to use long fallow periods to sustain food production under slash-and-burn systems, but rapid growth in population and land-use pressure have led to a reduction of fallow duration below the threshold required for the system to be sustainable.

Since the 1970s, many studies have shown that the increase in agricultural production in Africa has been achieved by a substantial increase in the area under cultivation, by expanding into marginal lands and bringing new forest areas under cultivation (Nkamleu and Manyong, 2005). This leads to the negative environmental consequences of deforestation, carbon loss, and loss of aboveground and belowground biodiversity. Due to the significant rates of population growth throughout Africa, land intensification had long been viewed as a crucial objective of the future of the agricultural sector. During the 1980s, stated key challenges of the future were to substitute extensification systems, with systems which are more intensive and use modern inputs, and the need to work toward a situation where output growth due to factor productivity will supplant the contribution of more inputs, with is not a sustainable strategy.

The present paper revisits the extensification-intensification paradigm in the African agricultural context, and explores the ability of land use pattern and technological progress to keep up with population growth. The focus is on investigating whether the production structure of the agriculture sector has changed during the last decades. In

particular, the study sheds light on the state of land use in the agricultural sector, and estimates how much growth in output is associated with growth in land area and other physical capital, and how much growth is due to total factor productivity (TFP). The rest of the paper is organized as follow: Section two describes the data used in the analysis. The theoretical framework is presented in section 3. Section 4 discusses the results while section 5 concludes the paper.

2. Data and coverage

The African continent is the focus of this study. The analysis is based on data drawn from FAOSTAT² system of statistics used for the dissemination of statistics compiled by the Food and Agriculture Organization (FAO). Data downloaded from FAOSTAT consisted of information on agricultural production and conventional and non-conventional inputs. Specification and definition of output and input data used in this study are as follows:

- *Agricultural production*: shows the value of the aggregate volume of agricultural production for each year express in 1999-2001 international dollars. They are based on the sum of price-weighted quantities of different agricultural commodities produced after deductions of quantities used as seed and feed weighted in a similar manner. The "international commodity prices" are used in order to avoid the use of exchange rates for obtaining continental and world aggregates, and also to improve and facilitate international comparative analysis of productivity at the national level. These "international prices", expressed in so-called "international dollars", are derived using a Geary-Khamis formula for the agricultural sector. This method assigns a single "price" to each commodity.

- *Labor* refers to the economically active population in agriculture for each year, in each country. The economically active population in agriculture is defined as all persons

² <http://faostat.fao.org>

engaged or seeking employment in agriculture, forestry, hunting, or fishing sectors, whether as employers, own-account workers, salaried employees, or unpaid workers. Since it was not possible to have information on differentials in skill levels and the number of hours worked on the farm, the economically active population in agriculture is the best proxy of labor input into the agricultural sector.

- *Agricultural land* is the sum of the areas under *arable land* (land under temporary crops, temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow), *permanent crops* (land cultivated with crops that occupy the land for long periods and need not be replanted after each harvest, such as cocoa, coffee, and rubber), and *permanent pastures* (land used permanently for herbaceous forage crops, either cultivated or growing wild).

- *Fertilizer*: Fertilizer consumption is often viewed as a proxy for the whole range of chemical inputs and more (Mundlak et al., 1997). Different countries use different amounts and types of fertilizers. Following other studies (Hayami and Ruttan, 1971; Rao et al., 2003), the sum of nitrogen (N), potassium (P_2O_2) and phosphate (K_2O) expressed in thousands of tons, that are contained in the commercial fertilizers consumed, is used as the measure of fertilizer input.

- *Tractors*: Data on agricultural capital are very scarce. Often, crude data on tractors and machinery have been used in cross-country analysis of agricultural production functions. We used data on the number of tractors, which refer to total wheel, and crawler tractors (excluding garden tractors) used for agricultural production.

- *Livestock*: Following Hayami and Ruttan (1971), the livestock input variable used in this study is the sheep-equivalent of five categories of animals. The categories of animals considered are buffaloes, cattle, pigs, sheep, and goats. Data on the number of these animals are converted into sheep equivalents using the following conventional conversion factors: 8 for buffalo and cattle; and 1 for sheep, goats, and pigs.

3. Method

The key issues relating to this study is the state of agricultural land expansion and the factors have accounted for the growth and development of the African agricultural sector over the past decades and what has been the role of land. Descriptive statistics are used to depict the agricultural land use in the continent. We then developed quantitative models to shed light on the sources of growth in African agriculture. We try to demonstrate how the interactions between factor endowments, technological innovation, and agricultural extension may have culminated in explaining agricultural production.

We have been able to put together consistent panel data on 26 countries from 1970 to 2000. The data series consisted of output represented by the value of agricultural production, and inputs to agricultural production which include labor, land and capital as described in section 2. The point of departure of our analysis is the neo-classical production function which is written as:

$$\ln Q_{it} = f(x_{ij}, t; \beta) + \varepsilon_{it} \quad \begin{array}{l} i = 1, \dots, n \\ t = 1, \dots, T \\ j = 1, \dots, J \end{array} \quad (\text{Eq 1})$$

Where Q_{it} is output of the i -th country in time period t , x_{it} is an $N \times 1$ vector of the logarithm of inputs for the i -th country in time period t , β is a vector of unknown parameters, and ε_{it} is random variable which assumed to be iid $N(0, \sigma^2_{\varepsilon})$.

The decomposition of the neo-classical production function to get the residuals is well known. We use this production function to break down the growth rate of aggregate output into contribution from the growth of inputs versus productivity change (Fulginiti et al., 2004; Limam and Miller, 2004):

$$\dot{Q}_{it} = \sum_j \alpha_{ij} \dot{x}_{ij} + TFP_{it} \quad (\text{Eq 2})$$

Where dots over variables indicate rate of change $\dot{X}_t = \frac{X_t - X_{t-1}}{X_{t-1}}$, and α_{ijt} is the output

elasticity of input j, for country i in time t. $\alpha_j = \frac{\partial f(x, t; \beta)}{\partial x_j}$

In our analysis, the aggregate production function in growth rates is given by:

$$\dot{Q}_{it} = c + \alpha_1 \dot{Land} + \alpha_2 \dot{Labor} + \alpha_3 \dot{Fertilizer} + \alpha_4 \dot{Tractor} + \alpha_5 \dot{Livestock} + \dot{TFP} + v_{it} \quad (\text{Eq 3})$$

That is:

$$\begin{aligned} \left(\begin{array}{c} \text{Growth rate} \\ \text{of output} \end{array} \right) - \left(\begin{array}{c} \text{Growth rate} \\ \text{of TFP} \end{array} \right) &= c + \alpha_1 \left(\begin{array}{c} \text{Growth rate} \\ \text{of land} \end{array} \right) + \alpha_2 \left(\begin{array}{c} \text{Growth rate} \\ \text{of labor} \end{array} \right) \\ &+ \alpha_3 \left(\begin{array}{c} \text{Growth rate} \\ \text{of fertilizer} \end{array} \right) + \alpha_4 \left(\begin{array}{c} \text{Growth rate} \\ \text{of Tractor} \end{array} \right) + \alpha_5 \left(\begin{array}{c} \text{Growth rate} \\ \text{of livestock} \end{array} \right) \end{aligned} \quad (\text{Eq 4})$$

We first compute TFP growth using Data Envelopment Analysis (DEA) procedure (Malmquist indexes). Then, regressing $\dot{Q}_{it} - \dot{TFP}$ on the growth rate of inputs, using panel data random effect procedure, we obtain coefficients which are interpreted as factor shares. For the pooled and for each period, a separated panel data random effect regression was ran to derive factor share for each of the period (1971-80, 1981-90, 1991-00 and 1971-00). The estimating equation is equation 4, where the constant accounts for omitted variables (omitted variables include physical variables such as pesticides as well as less physical factors such as agro-climatic conditions, institutions and political instability...).

Malmquist index methods described in Fare et al. (1994), Coelli et al. (1998), Nkamleu (2010) are used to compute total factor productivity. This approach, when panel data are available, uses DEA-like linear programs and the Malmquist total factor productivity (TFP) index to measure productivity change and to decompose this productivity change into technical change and technical efficiency change. The Malmquist TFP index is defined using distance functions. Input distance functions and output distance functions

can be defined. An output distance function considers a maximal proportional expansion of the output vector, given an input vector. The output distance function is defined on the output set $P(x)$, as: $d_0(x, y) = \min\{\theta : (y/\theta) \in P(x)\}$,

where the output set, $P(x)$ represents the set of all output vectors, y , which can be produced using the input vector x . For the single-output, single-input and output-oriented case, and following Fare et al. (1994), the MI TFP change between the base period 's' and a period 't' can be written as:

$$m_0(y_s, x_s, y_t, x_t) = \frac{d_0^t(y_t, x_t)}{d_0^s(y_s, x_s)} \left[\frac{d_0^s(y_t, x_t) d_0^s(y_s, x_s)}{d_0^t(y_t, x_t) d_0^t(y_s, x_s)} \right]^{1/2}, \quad (\text{Eq 5})$$

where the notation $d_0^s(y_t, x_t)$ represents the distance from the period t observation, to the period s technology. A value of 'm' greater than one will indicate positive TFP growth from period s to period t. In (5), the term outside the square brackets measures the Farrell efficiency change between period s and t, and the term inside measures technical change, which is the geometric mean of the shift in the technology between the two periods. Thus, the two terms in equation (5) are:

$$\text{Efficiency change} = \frac{d_0^t(y_t, x_t)}{d_0^s(y_s, x_s)} \quad (\text{Eq 6})$$

$$\text{Technical change} = \left[\frac{d_0^s(y_t, x_t) d_0^s(y_s, x_s)}{d_0^t(y_t, x_t) d_0^t(y_s, x_s)} \right]^{1/2} \quad (\text{Eq 7})$$

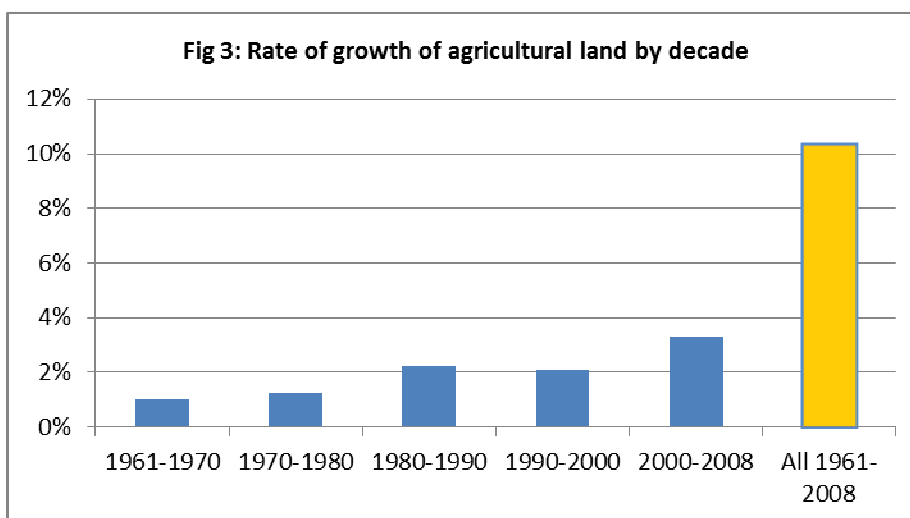
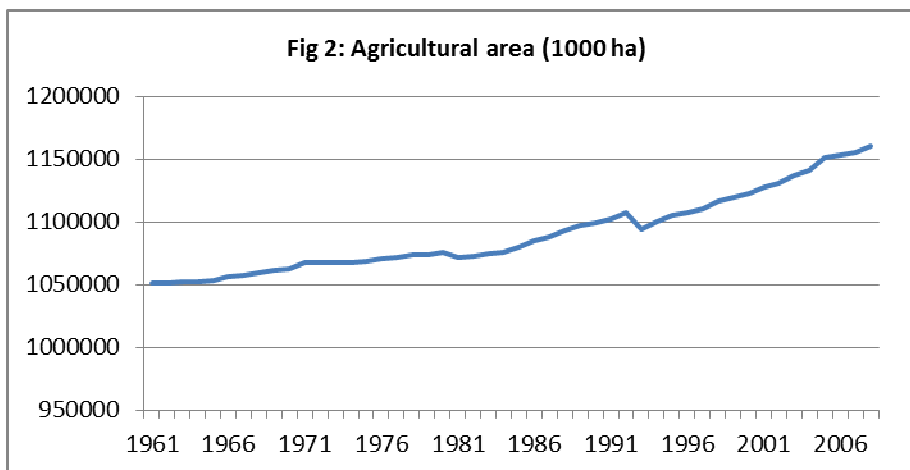
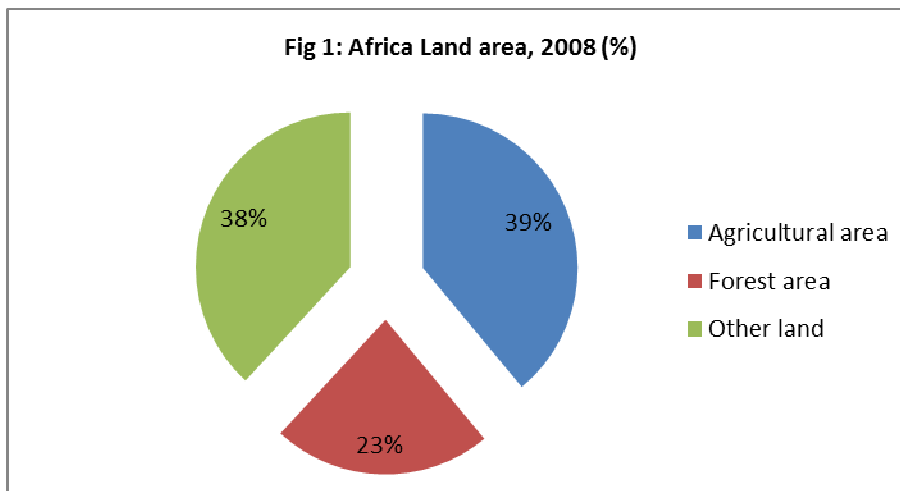
The efficiency change component can be separated into a scale efficiency and pure technical efficiency change. The pure technical efficiency is obtained by re-computing efficiency change under variable return to scale ($\text{EFFCH}_{\text{vrs}}$). The scale efficiency is, therefore, the ratio of efficiency under constant return to scale and the same efficiency under variable return to scale ($\text{EFFCH}_{\text{crs}}/\text{EFFCH}_{\text{vrs}}$). The overall index in (5) represents the productivity of the production point (y_t, x_t) relative to the point (y_s, x_s) , and a value larger than one depicts positive TFP growth between periods s and t.

4. Results

4.1. Land use in African agriculture: what do we know?

At present some 39 percent (over 1.1 billion ha – Figure 1) of the Africa's land surface (2.9 billion ha) is used for agriculture (Agricultural land is the sum of arable land, land under permanent crops and land under permanent meadows and pastures). The fact that there remain some 0.7 billion ha of forest suggests that there is still scope for further expansion of agricultural land. However, there is also a perception, at least in some quarters, that there is no more, or very little, land to bring under cultivation. Much of the remaining land suffers from constraints such as ecological fragility, low fertility, toxicity, and high incidence of disease or lack of infrastructure. These reduce their productivity, require high input use and management skills to permit their sustainable use, or require prohibitively high investments to be made to make them accessible or disease-free.

The quantity of land in use for agricultural purpose in Africa is obviously high, but more alarming is the increasing rate of new land conversion. Due to the significant rates of population growth throughout Africa, there is a sense that too many farmers are trying to produce simply by expanding into new land. African agricultural land has been constantly increasing since 1961 (Figure 2). From 1.05 billion ha in 1961, the agricultural land represents slightly over 1.16 billion ha today, denoting an increase of more than 10%. Remarkably, since 1980 the rate of growth of agricultural land use is higher and seems to accelerating (Figure 3).

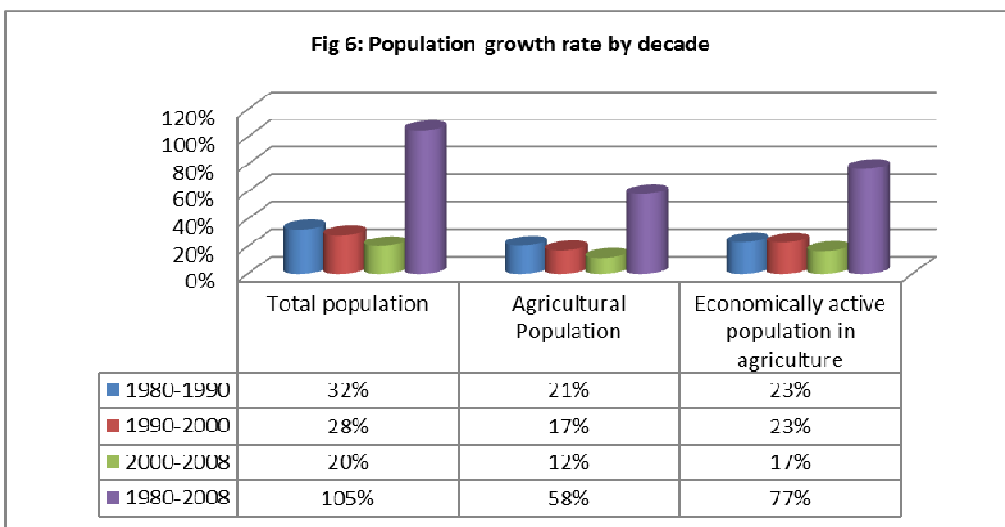
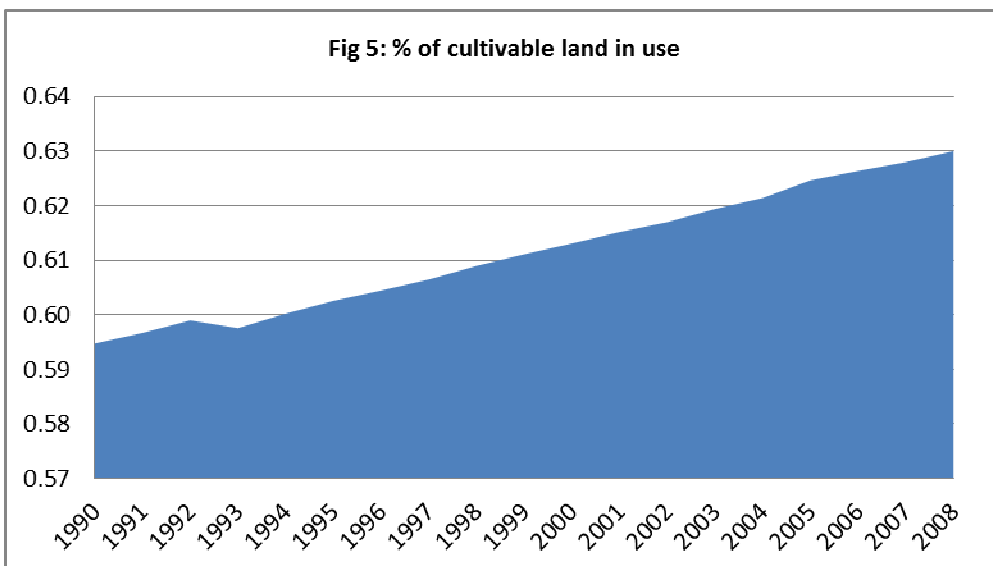
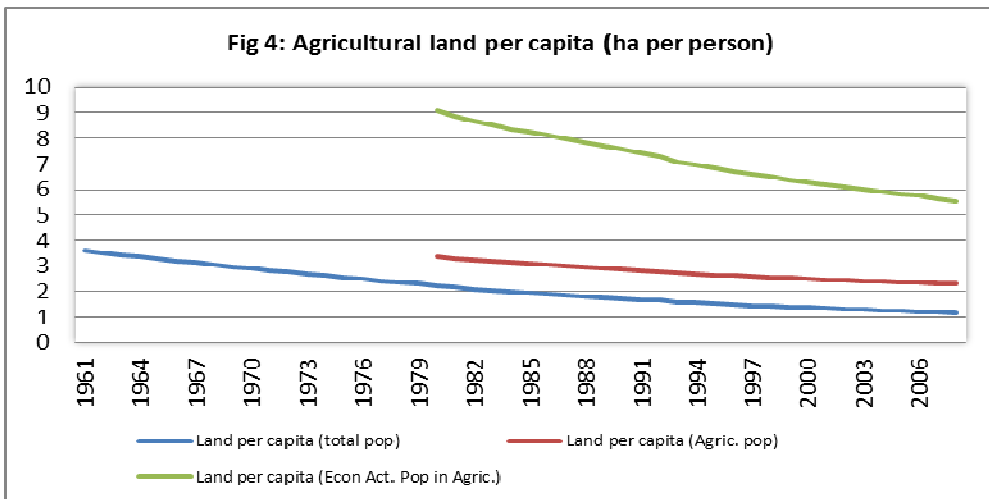


Concerns are voiced that African farmers might in the not too distant future no longer be able to find land for food production. Such fears are not illusive. The continuing decline of agricultural land per person (Figure 4) is prominent and is an indicator of impending problems. Agricultural land per capita for the entire population has decreased by more than half between 1961 and 2008. The trend is similar for the land per agricultural population, or the economically active population in agriculture.

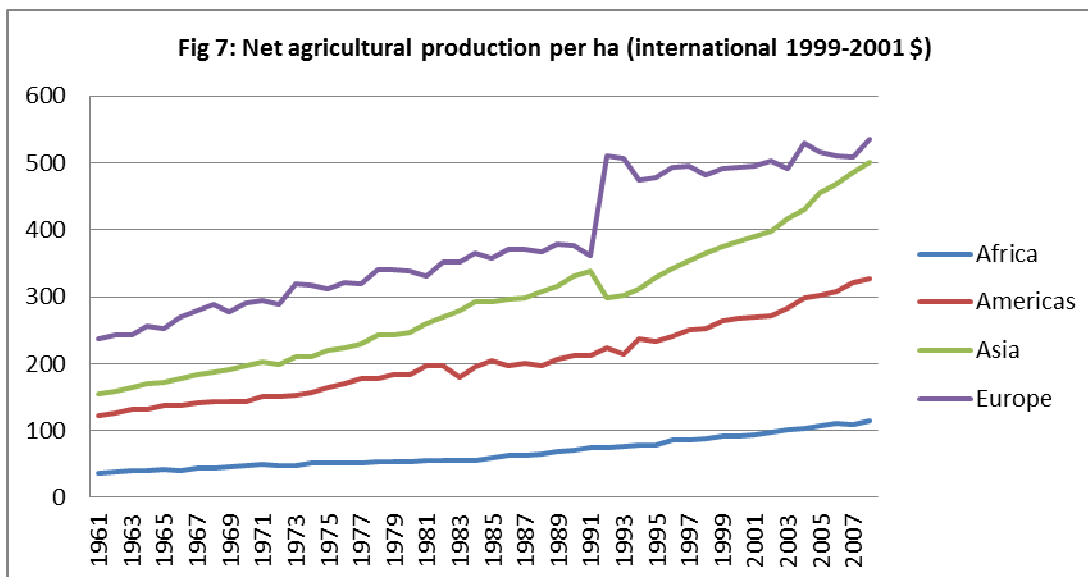
If we look at the ratio of agricultural land over the total cultivable land³, it appears that agricultural production is presently using 63% of the potential cultivable land, which is quite high (Figure 5). More, from 1990 to 2008, the proportion of use of cultivable land has increase by nearly 4 points. If this trend continues, the vacant lands for agriculture will be exhausted in less than 2 centuries.

This again confirms that scarcity of agricultural land is becoming a real survival problem. The problem is amplified by the growing number of both people to feed, and people seeking work in agriculture. At the very least, agricultural growth must match population growth to avoid the “Malthusian trap” and stagnant development. The figure 6 shows that between 1980 and 2008, African population more than doubled. One also observed a similar type of evolution when considering the trend of both agricultural population and economically active population in agriculture. *Agricultural population* is defined as all persons depending for their livelihood on agriculture, hunting, fishing and forestry. It comprises all persons economically active in agriculture as well as their non-working dependents. *Economically active population in agriculture* (agricultural labor force) is that part of the economically active population engaged in or seeking work in agriculture, hunting, fishing or forestry). Given these unprecedented rate of population growth throughout Africa, land intensification and increasing productivity is no longer a choice, it is a must for the survival of the agricultural system.

³ Total cultivable land is defined here as the sum of agricultural land and forest land.

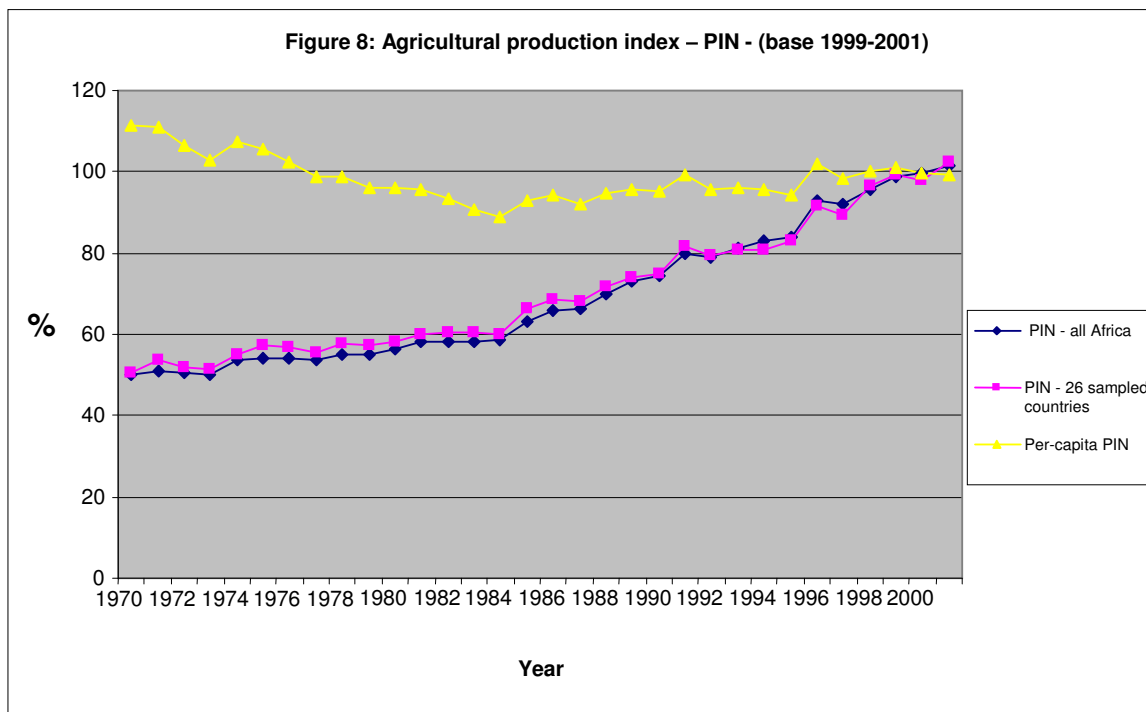


Unfortunately, land productivity is still relatively very low. In recent years, much effort has been put into trying to raise productivity in African agriculture, and calls have been made for more investment in agricultural science and technology for Africa. The reasons for this seem evident when one considers both the initial difference in agricultural productivity and the dissimilarity of the productivity growth in Africa when compared with other continents. Figure 7 shows the values for land productivity, measured as the value of aggregate agricultural output per hectare of agricultural land in constant 1999-2001 international dollars. We can see that in all continents, agricultural land productivity has increased considerably except Africa where only a marginal increase is observed.



4.2. Driven force of Agricultural growth: factor accumulation vs productivity

Figure 8 shows the evolution of the nominal agricultural production index for the African continent and the 26 countries in our sample. The index of agricultural production which was equal to 50% in 1970, increased to 101% in 2001. In other words, there has been a doubling of the nominal agricultural production in the continent during the last three decades. This performance is well below the tripling of the agricultural production achieved on average by the developing countries as a whole. During the same period, the agricultural production index of all developing countries rose from 34% to 100%. The situation is even less encouraging when the per-capita index of agricultural production is examined. The per capita index which was 111% in 1970 had decreased to 99% in 2000, revealing that agriculture and food crop production are not increasing at a rate necessary to meet African population growth. This again brings out the Malthusian specter of impending disaster from population increasing faster than agricultural output.



Using the methodology described in section 3, we have disentangled contribution of different parameters in the agricultural output growth. Table 1 reports the results of the contribution of factor inputs and productivity change. These results are reported by decade, over the entire sample. Globally, the contribution of factor inputs (98%) has been on average larger than that of total factor productivity - TFP - (67%). Unaccounted factors which might include factors such as agro-climatic shocks, institutions and political instability, also contributed importantly to constraint agricultural output growth (-65%). The weak performance of the TFP growth over the 1970-2000 period was mainly due to its negative evolution during the seventies. In the eighties and nineties, TFP growth rose sharply, while the contribution of factor inputs tended to decline. Busari et al, (2005), also found that TFP contribution to total economic growth was negative during the seventies in Africa. Fulginiti et al. (2004), studying African agricultural productivity over the 1960-1990 period, also find that the seventies were the only decade where average TFP change were negative. In the eighties, the findings show clearly that productivity provided the most important component of the output growth. But globally over the entire period, output growth decomposition shows that physical inputs or factor accumulation provided the most important component of output growth during the last three decades.

Table 1: Productivity and factor accumulation percentage contribution to agricultural growth

	1971-80	1981-90	1991-00	All (1971-2000)
Total output growth per year (a)	100%	100%	100%	100%
Total growth due to factor inputs (b)	113.88%	48.33%	92.04%	98.41%
Yearly growth due to Total factor productivity change-TFP (c)	-45.11%	86.14%	91.36%	66.95%
Yearly growth due to unaccounted factors (d)	31.23%	-34.47%	-83.39%	-65.35%

$$(a) = (b)+(c)+(d)$$

Agricultural growth is fueled by factor productivity (intensification) and factor accumulation (extensification). The previous section showed that in sum, physical inputs,

or factor accumulation globally provided the most important component of output growth during the last three decades.

Narrowing our focus within the contribution of each physical input reveals that output growth due to fertilizer usage is the highest in Africa where it accounts for 51% of total agricultural output growth, following by the contribution of tractor (25%). The amount attributable to labor growth was 21% while land account only for 4% of total agricultural growth. The contribution of livestock has been constantly negative (Figure 9). Table 2 reports results of the decomposition of the source of output growth by decade. These results indicate that in the time dimension, we observe more stability in the contribution of fertilizer, as well as in the contribution of livestock. The contribution of tractor was more prominent in the seventies, while labor contribution appears more apparent and important in the 1990s. In all the three decades, fertilizer has been one of the most important physical input contributors to agricultural growth, suggesting that fertilizer had a good foundation, on which one can build strong agricultural growth in Africa. The contribution of land appears to still be positive. As previously stressed, new land cannot be indefinitely available for agricultural purpose. The contribution of land will slowly and inevitably come close to zero. The system therefore needs to be prepared for such an eventuality and act in such a way as to adapt to this new reality. Once again, technological progress will be central.

The negative contribution of unaccounted factors with increase between 1990 and 2000, roughly counter-balanced the contribution of the productivity change. This shows how exogenous factors such as conflicts and agro-climatic shocks have jeopardized past efforts and should not be neglected in future strategies. Globally, differences in the growth of internal resources (land and livestock), modern technical inputs (fertilizer and machinery), and man power (labor) have all contributed to the observe difference in output change. We do not attempt to explore the economic and institutional factors that have led some countries and regions to make the investments necessary to supply more input to their farmers.

Figure 9: Contribution of physical inputs to the African agricultural growth, 1971-2000

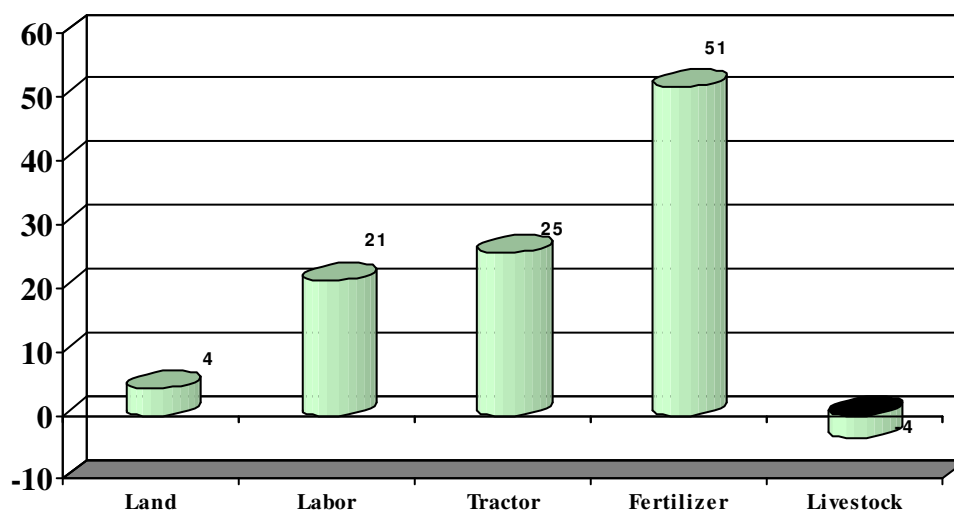


Table 2: African agricultural growth decomposition by decade.

Source of growth (annual growth rate in percentage)

	1971-80	1981-90	1991-00	All (1971-2000)
Total output growth per year (a)	100%	100%	100%	100%
Total growth due to factor inputs (b)	113.88%	48.33%	92.04%	98.41%
Yearly growth due to Land (c)	-13.51%	5.39%	3.06%	4.14%
Yearly growth due to Labor (d)	-14.77%	-34.76%	30.06%	21.04%
Yearly growth due to Tractor (e)	88.10%	13.12%	14.79%	25.44%
Yearly growth due to Fertilizer (f)	57.40%	67.82%	44.90%	51.31%
Yearly growth due to Livestock (g)	-3.34%	-3.23%	-0.77%	-3.54%
Yearly growth due to unaccounted factors (h)	31.23%	-34.47%	-83.39%	-65.35%
Yearly growth due to Total factor productivity change (i)	-45.11%	86.14%	91.36%	66.95%

*Arithmetic mean

(a) = (b)+(h)+(i) ; (b) = (c)+(d)+(e)+(f)+(g)

5. Conclusions

This paper has used the broader framework provided by empirical growth literature and recent development in TFP measurement to search for fundamental determinants of growth in African agriculture and explore the role of land resource in agricultural production. The following findings emerged from the study:

1 – The results share the view that factor accumulation accounts for a large share of agricultural output growth. The contribution of traditional factor inputs to overall agricultural growth has been on average larger than that of TFP.

2 – We also highlighted the fact that uncontrolled factors such as agro-climatic shocks, institutions and political instability, contributed importantly to constraint agricultural output growth in Africa. Therefore there is a need to turn some uncontrollable factors into controllable factors (example; we should work to partly control climate change by putting more resources/effort on mitigation measures).

3 – In relation to land resources, we found that land is not an inexhaustible resource; in fact the system is getting closer to the limit. The system therefore needs to be prepared for such an eventuality and once again, technological progress will be central.

4 – Land productivity is still relative low. Though land productivity has increased over the years, its level and its growth rate is still small compared to what is needed to cope with population growth.

These results have important implications for policy targeting in the context of the food crisis and need for more greening agriculture, and should be taken into account to build strategies to overcome the problem of agricultural growth in Africa on a sustainable basis.

References

- Busari D. T., A. A. Amin and T. Ntilivamunda, 2005. Modeling total factor productivity in African economies. Tenth annual conference on econometric modeling in Africa, 6-8 July 2005, Nairobi Kenya.
- Coelli, T.J., D.S.P. Rao, and G. Battese, 1998. Introduction to efficiency and productivity analysis. Kluwer Academic Publisher, Boston.
- Fare R.S., S. Grosskopf and C.A.K. Lovell, 1994. "Production Frontière. Cambridge University Press, Cambridge, UK.
- Fulginiti, E.L., Perrin, R.K., and Bingxin, Y., 2004. Institutions and Agricultural productivity in Sub-Saharan Africa. *Agricultural Economics* 31 (2004) 169-180.
- Hayami, Y., and Ruttan, V. W., 1971. *Agricultural Development: International perspective*. Baltimore: John Hopkins University Press.
- Limam Y. R., and S. M. Miller, 2004. Explaining economic growth: Factor accumulation, total factor productivity growth, and production efficiency improvement. Department of economic working paper series 2004-20. Connecticut University.
- Mundlak Yair, Donald F. Larson, and Rita Butzer, 1997. The determinants of agricultural production: a cross country analysis. World Bank policy research working paper No 1827.
- Nkamleu, G.B., 2004a. Expliquer l'échec de la croissance de la productivité agricole en Afrique francophone: analyse non paramétrique de l'efficacité et du changement technologique du secteur agricole. *Economie Rurale* 279: 55-67.
- Nkamleu, G.B., 2004b. Productivity growth, technical progress and efficiency change in African agriculture. *African Development Review* 16(1): 203-222.
- Nkamleu, G.B. and Manyong, V.M. (2005). Factors affecting the adoption of agroforestry practices by farmers in Cameroon. *Small Scale Forest Economics, Management and Policy*, Vol. 4 No. 2. The University of Queensland, Australia.
- Nkamleu, G.B., 2010. Root Causes of the Food Crisis: Technological Progress and Productivity Growth in African Agriculture. *Nova-Publisher, NY, USA*. P.149.
- Rao, D.S.P., O'donnell, J., and Battese, G.E., 2003. Metafrontier functions for the study of inter-regional productivity differences. *Centre for Efficiency and Productivity Analysis Working Paper* 1.