# Poverty and Food Security in Burkina Faso: Analysis of Dynamics at Work and Impacts of Public Investment in Agriculture

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## Abstract

This article uses a CGE model to analyze the impacts of a possible downward trend of agricultural productivity in Burkina Faso. It also explores the impact of public investment in agriculture. The results shows the very high sensitivity of consumption levels of the poor to the level of agricultural productivity. While the current situation is already hard for rural as well as urban poor, a decline in agricultural productivity is likely to plunge them into an acute food shortage. In contrast, public investment in agriculture, through its positive impact on agricultural productivity is effective in the fight against poverty and food insecurity. Changes of agricultural productivity influence food consumption of the poor mainly through a strong variation in agricultural prices and real incomes.

Key Words: Food security, Poverty, Computable General Equilibrium

## 1. Context and Issue

Burkina Faso is an agricultural-based country. Over 80% of the active population derives its income from agriculture, and the primary sector accounts for over 30 percent of GDP. Agriculture plays a major role in household food security by providing households with incomes and by supplying markets. Domestically produced millet, sorghum and corn account for 80% of households' grain consumption, and 40% of the country's rice consumption is produced domestically. Since 1995, Burkina Faso has recorded a 6% annual GDP growth. This growth rate is greater than that of the previous two decades as well as the average growth rate of the other countries members of the WAEMU[1] (World Bank, 2012). Despite this growth rate, poverty remains at high level (46.7% in 2009) (World Bank, 2012) while about 26% of the population is still considered as undernourished (FAO, 2013). The great majority of Burkina Faso's population is therefore vulnerable and exposed to high food insecurity.

Burkina Faso's cereal productivity is among the lowest in the world and has experienced a relative stagnation over the past two decades (FAO and IFAD, 2013; Tittonell and Giller, 2013). Agriculture faces major constraints which hamper its productivity. Scientific studies on nutrients balance evaluation and surveys among peasants support the idea that natural resources depletion and land degradation are important concerns in this country (Gray, 1999; Lindqvist and Tengberg, 1993; Taonda et al., 1995; Visser et al., 2003). High population growth without growing off-farm jobs opportunities, combined with low input techniques, translates into growing pressure on natural resources (OECD, 2012). Moreover, climate change may deteriorate agricultural production conditions (IPCC, 2007).

Public infrastructure may partly change the situation. Actually the lack of public goods in rural area discourages private investment and hamper agriculture profitability. In such a context, it is not unreasonable to fear a future decline in agricultural productivity (FAO, 2012) but the reverse trend is also possible. Public investment is expected to reduce the risk and increase the profitability of private investment for enhancing incentives for farmers to invest (Anderson et al., 2006).

What are the expected consequences of a loss in agricultural productivity on economic growth and food security, in a landlocked sahelian country as Burkina-Faso, highly dependent on natural resources? Are urban households likely to experience the consequences of agricultural productivity degradation as well? By contrast which consequences have to be expected in case on an agricultural productivity growth?

A dynamic Computable General Equilibrium (CGE) model is used because of its ability to take into account agricultural and non-agricultural linkages and to easily represent productivity change by varying the scale parameter of the production function – commonly considered as productivity parameter or total factor productivity (TFP) (Pauw and Thurlow, 2011). CGE models are indeed suited for economywide impacts analysis of exogenous or policy shocks on agricultural sector (Hertel, 2002). Moreover, this tool is particularly interesting for a study on food security because it allows to consider simultaneously the impacts on food production due to the agricultural productivity changes and its consequences not only on households' consumption but also on

[1] West African Economic and Monetary Union

sectors using agricultural products as inputs. It is so possible to consider the direct impact through agricultural price variation and the indirect one through production factors earnings variation.

After describing the CGE model and data, we present three alternative scenarios – including two scenarios of agricultural productivity decline assumption and a public investment in agriculture – simulated with the CGE model (section 2). Section 3 analyzes and discusses simulation results while section 4 summarizes findings and policy recommendations.

## 2. Model and data

### 2.1. The CGE Model

The CGE model used for this study is directly adapted from the ID3 model developed at CIRAD[2] (version without imperfect information). It is a recursive dynamic model that works on a yearly time step.

*2.1.1. General characteristics*

It is a classical CGE model: (i) consumer maximizes utility subject to an income constraint; (ii) producer maximizes profit subject to a technical constraint defined by production function, (iii) consumers hold fixed factors (Capital, Land and Labor), so that the remuneration of these factors form their income, (iv) the quantities of supplied goods are equal to the quantities requested; (v) the market equilibrium is instantaneous and determines the quantities produced and consumed, imports and exports for various goods as well as prices of goods and services and remuneration of production factors; (vi) government's budget balances expenditure (government consumption and transfers) with revenues from various taxes as well as transfers from the rest of world (Official Development Aid); (vii) imperfect substitution between goods produced in different countries (Armington) has been retained.

For the sake of realism, some changes were introduced into the basic CGE model. These changes include labor mobility; unemployment; dynamics of population and capital accumulation as well as externalities deriving from public investment in agriculture.

*2.1.2. Labor mobility*

Imperfect labor mobility is modeled to represent the difficulty for the labor force to move from one major sector to another due to specific jobs skills and the difficulty of vocational retraining. This is particularly true when considering both time length (short-to-medium run) and the situation of developing countries where public support services for professional retraining are lacking. Four major sectors have been identified (agriculture, agro-industries, other industries and services). Labor is then assumed to be perfectly mobile only between sectors belonging to the same major sector (e.g. agricultural labor can move from rice sector to corn sector but never to sector of education). This implies that wage for each type of labor is aggregate sector specific. Labor mobility assumption is critical in determining the capacity of the productive sectors to adjust in case of exogenous or policy shocks.

[2] See Gérard et al. (2002) for the full equations listing and detailed justifications of the formulations chosen

*2.1.3. Unemployment*

Unemployment is included in the model and affects the salaried labor both in agricultural and non-agricultural sectors. Wages are assumed to be rigid and market equilibrium is ensured by quantities. By contrast self-employed workers as well as family labor have flexible wages. Initial levels of unemployment have been set at 18% for non-agricultural salaried labor and at 1.1% for agricultural salaried labor, corresponding respectively to 2005 urban and rural unemployment rates (INSD, 2008). The growth in activity can then lead to a growth in the volume of salaried labor, which implies a decline in unemployment rather than an increase in wages as is the case in full employment assumption. When all workers are employed, the wage increases to achieve balance (Li and Yang, 2012).

*2.1.4. Dynamics*

The dynamics of the model is based on population growth and capital accumulation. The population is expected to grow annually at an exogenous rate of 3%, corresponding to current growth rate. This growth has the effect of increasing labor supply and demand for goods and services. Domestic savings and current account balance determines the level of investment available in the economy. Investment in each sector is a fixed share of total savings and is added to the capital (net of depreciation) from previous periods to determine the capital available to this sector for the next period.

*2.1.5. Modeling the impact of public capital externalities*

In order to take into account the public capital in the model, it is assumed that it affects total factor productivity according to an elasticity (Estache et al., 2012).). The externality effect of public capital goes through the ratio of public capital stock in the current period ($Kpub_t$) and its stock in the previous period ($Kpub_{t-1}$). The ratio enable taking into account the difference of impact according to the level of country's capital endowment. The more it is equipped with at *t-1*, the less an additional unit of capital at *t* has impacts. In line with Dumont and Mesplé-Somps (2000) and Adam and Bevan (2006), we consider that capital stock is the main determinant of agricultural productivity level rather than the flux of investment as assumed by Estache et al. (2012).

The production function is of the following form:

$$XD_{i,t} = \chi_{i,t}\left(\eta_i \cdot CI_{i,t}^{-\phi_i} + (1-\eta_i)\cdot VA_{i,t}^{-\phi_i}\right)^{-1/\phi_i} \quad (1)$$

where $XD_{i,t}$ is the production of sector *i* at period *t* ; $CI_{i,t}$ the level of intermediate consumption of sector *i* period *t* ; $VA_{i,t}$ value added of sector *i* at period *t* ; $\eta_i$ et $\phi_i$ are parameters of production function ; $\chi_{i,t}$ the productivity of sector *i* at *t* ;

Agricultural productivity is defined by:

$$\chi_{i,t} = \chi_{i,t-1} \cdot \prod_{kp}\left(\frac{Kpub_{kp,t}}{Kpub_{kp,t-1}}\right)^{elastpub_{kp}} \quad (2)$$

The index *kp* refers to the type of public capital. The model distinguishes six types: agricultural extension, agricultural Research and Development, rural roads, rural electrification, rural education and irrigation*;*

$elastpub_{kp}$ is the elasticity of agricultural productivity with respect to public capital *kp*. The elasticity defines the percentage increase in agricultural productivity associated with each unit of public capital. It is therefore a key parameter that will largely determine results. Values differ widely in the literature based both on the context and on the method used to estimate them. For this study, the lowest elasticities found in the literature are used (Table 3).

As can be seen in equation (2), public investment enables accumulation of productivity gains over time.

The public capital stock depreciates at a constant rate ($dep$) while investment policies increase this stock.

$$Kpub_{kp,t} = Kpub_{kp,t-1} \cdot (1 - dep) + IPUB_{kp}/CKP_{kp} \quad (3)$$

where $IPUB_{kp}$ and $CKP_{kp}$ are respectively the amount invested in the public capital *kp* and its unit cost. $IPUB_{kp}$ is a public policy variable. It is an annual investment objective by type of capital fixed by the public authority.

### 2.2. Data

#### *2.2.1. A Social Accounting Matrix for Burkina Faso in 2005*

The Social Accounting Matrix (SAM) used in this study was constructed for the reference year 2005 by Burkina Faso's Ministry of Agriculture, Fisheries and Hydraulic Resources (currently the Ministry of Agriculture and Food Security). It includes:

- 25 sectors (including 11 agricultural sectors) producing 22 goods and services for final or intermediate consumption;
- five production factors (agricultural and non-agricultural salaried labor, agricultural family labor, agricultural and non-agricultural capital)
- a savings-investment account;
- a rest of the world account; and
- four types of households.

In 2005, agriculture's contribution to national GDP was 35%, compared to 22% for industry and 43% for services. Traditional grains – millet, sorghum and fonio – are the largest contributors to agricultural GDP (33%), followed by livestock (27%), cotton (12%) and other agricultural products (10%). Export revenues mainly come from agricultural products (57%). These exports concentrate on cotton, which alone accounts for 45% of total export value. Most of the country's imports are non-agricultural products (93%) and 80% of agricultural products imports consist of rice, followed by other agricultural products (10%) and fruit (7%).

In Burkina Faso, domestic production ensures the essential of food intake. As shown in Table 1 only rice and fruits represent a significant share of imports in total absorption (57% and 38% respectively). Exports are focused on cotton, minerals and fruits (respectively 80.85%, 39.79% and 27.38%). This weak relationship with international trade can be explained by the country's remoteness and poor transport infrastructures (roads, railways ...)

**Table 1:** Share of exports/imports in total production/absorption (%)

| | Imports | Exports |
|---|---|---|
| Corn | 0.36 | 0.47 |
| Rice | 56.67 | 0.71 |
| Other Cereal (millet, sorghum, fonio) | 0.00 | 0.15 |
| Vegetables | 2.00 | 6.98 |
| Groundnuts | 0.01 | 0.52 |
| Cotton | 0.05 | 80.85 |
| Fruit | 38.06 | 27.38 |
| Livestock | 0.08 | 6.13 |
| Other agricultural products | 5.14 | 6.84 |
| Minerals | 22.18 | 39.79 |
| Meat_Fish | 0.10 | 1.76 |
| Textile | 27.54 | 6.70 |
| Fertilizer | 72.78 | 4.83 |
| Other industrial products | 45.88 | 9.39 |
| Restoration | 0 | 0 |
| Transport | 13.81 | 0.50 |
| Other market services | 2.45 | 2.02 |
| Education | 0 | 0 |
| Health | 0 | 0 |
| 'Other non-market services | 9.13 | 7.95 |
| Trade | 0 | 0 |

*Source: SAM Burkina 2005*

The four households groups distinguished in the SAM reflect the diversity of households in terms of endowment factors and food situation. National poverty line of 83 000 CFA capita$^{-1}$ year$^{-1}$ distinguishes the poor from the non-poor. These groups are representative of the situation of about 6 million of poor in rural areas, 600 000 of poor in urban areas, 5 million of non-poor in rural areas, and 2 million of non-poor in urban areas. Annual incomes per capita are about 62 100 CFA francs for the rural poor, 56 000 CFA francs for the urban poor, 201 000 CFA francs for the rural non-poor and 291 000 CFA francs for the urban non-poor. Income sources are organized as follows: 72% of the incomes of the rural poor comes from agricultural activities and 28% from non-agricultural activities; 68% of the incomes of the urban poor comes from agricultural activities and 32% from non-agricultural activities; 53% of the incomes of the rural non-poor comes from agricultural activities and 47% from non-agricultural activities; and 7% of the incomes of the urban non-poor comes from agricultural activities and 93% from non-agricultural activities.

Food consumption levels – converted to kilogram capita$^{-1}$year$^{-1}$ for this study in order to have a more realistic vision of the food situation- are presented in table 2. In Burkina Faso, grains (millet, sorghum, fonio, rice and corn) play a major role in food security. They account for more than 42% of households' food expenditure and constitute the main source of energy intake while meat and fish provide essential animal protein. These consumption levels are then compared to the levels recommended for Burkina Faso by Permanent Interstate Committee for Drought Control in the Sahel (CILSS, 2004): 203 kg/capita/year for grain and 14 kg/capita/year for meat/fish. The situation seems worst for poor households. The per capita income for rural poor is 25% below the poverty line and 32% for the urban poor. Similarly, the levels of per capita grain and meat/fish

consumption indicate high food insecurity for poor. Indeed, grain consumption by the rural poor is 14% below the level recommended by CILSS and 33% below this figure for the urban poor.

**Table 2 :** Annual Per Capita Income and Grain Consumption (year 2005)

| | per capita income (CFA francs)* | corn consumption (kg) ** | rice consumption (kg) | other grain consumption (kg)*** | grain consumption (total) | meat/fish consumption (kg) |
|---|---|---|---|---|---|---|
| Rural Poor | 62101 | 40 (23%) | 15 (8%) | 120 (69%) | 175 | 10 |
| Urban Poor | 56073 | 68 (50%) | 25 (18%) | 43 (32%) | 136 | 8 |
| Rural Non-Poor | 201862 | 74 (28%) | 41 (16%) | 145 (56%) | 260 | 31 |
| Urban Non-Poor | 291984 | 90 (41%) | 80 (37%) | 47 (22%) | 217 | 38 |

* Poverty line is set at approximately 83,000 CFA francs for the base year (2005) (€127/per person/year)

** Percentages of actual grain consumption in total grain consumption are given in parentheses.

*** Other grains consist of millet, sorghum and fonio.

Source: Authors' estimates based on SAM data.

*2.2.2. Estimating de level and cost of public capital*

The value of the stock of public capital in the base year (2005 or nearest year) has been estimated by combining the literature review and experts opinions (table 3). In 2005, the number of extension staff for 10 000 producers was estimated to only 1. It is not surprising that many producers do not benefit from extension services on several agricultural seasons. Similarly, the number of researchers involved in agriculture (240) reflects the weakness of public capital in Agricultural Research and Development (Stads and Kaboré, 2010). Road infrastructure is poorly developed (56 km $1000^{-1}$ $km^2$), impractical when it rains. Only 15% of the rural population is connected to electricity in 2007 (Ministère des mines des carrières et de l'Energie (MMCE), 2007). The literacy rate is globally low (29% in 2007) due to a rural population largely illiterate (World Bank, 2012) while irrigation infrastructure enables using only one third of the potential irrigable land.

**Table 3:** Stock, Costs and elasticities of capital public

| Type of public capital | Measure | Stock in 2005 | Objective stock in 5 years | Annual investmen t objective | Annual cost* | Unit cost* | Cost over 5 years* | Elasticities** | Sources of costs and stocks estimation |
|---|---|---|---|---|---|---|---|---|---|
| Extension | number of extension agents | 1 136 | 6 674 | 1 108 | 2 018 | 1.82203 | 10090 | 0.039 | Experts opinions |
| R&D | number of Researchers in Agr | 240 | 520 | 56 | 1 020 | 18.2203 | 5100 | 0.027 | Stads and Kaboré (2010) |
| Roads | Distances (Km) | 46 095 | 59 924 | 2 766 | 41 486 | 15 | 207430 | 0.042 | FAD (2004) |
| Electricity | Rural population with access (%) | 15 | 26 | 2 | 6 300 | 3000 | 31500 | 0.001 | MMCE (2007) |
| Education | Rural population being literate | 1369062 | 3 308 560 | 387 899 | 8 048 | 0.020748 | 40240 | 0.047 | Van Ravens and Aggio (2007) |
| Irrigation | Irrigated area (ha) | 20 000 | 34 000 | 2 800 | 28 000 | 10 | 140000 | 0.036 | OCDE (2012) |

*Million CFA

**Elasticities used in this paper are the lowest fund in the literature

## 2.3. Scenarios

The model is used to perform four simulations: the baseline which is calibrated on recent Burkina Faso's economic trends, two scenarios representing a loss in agricultural productivity-optimistic (-0.5% per year) and pessimistic (-1.5% per year) and finally a scenario of public investment in agriculture which positively impacts agricultural productivity (around +2% per year during five year)

### *2.3.1. Agricultural productivity decline scenarios*

As explained above, agricultural productivity in Burkina Faso, unlike other parts of the world, has been relatively stagnant over the past few decades due to natural, socio-economic and institutional factors. Despite the large capacity of producers to implement different techniques to avoid downward trend productivity, there is a legitimate concern that the situation become more and more difficult due to thresholds effects and that the only private strategies are not sufficient to avoid such a trend in the future. Agricultural productivity decline can have catastrophic consequences on vulnerable population, particularly in a context of agricultural land depletion (OECD, 2012). In order to analyze in detail these consequences, we simulate an optimistic scenario of 0.5% annual decline of agricultural productivity and a pessimistic scenario of 1.5% annual decline.

### *2.3.2. Public investment in agriculture*

In this scenario, we implement an investment program over 5 years in order to increase the stock of public capital in agricultural sector. Some objective stock – namely extension staff and education – are fixed taking into account the growth of rural population. For public capital "extension", the objective is to move from one staff for 10 000 producers to five staffs for 10 000 producers, and this imply having 6674 staffs in 2015 across country. For agricultural Research and Development, the goal consists in increasing the number of researchers involved in agriculture from 240 to 520 in 2015. A 30% increase in rural roads is assumed in 2015 while the share of rural population connected to electricity is expected to increase from 15% to 26%. Rural literacy rate estimated to 13% for the base year is expected to reach 26% in 2015. Regarding irrigation infrastructure, the objective is to increase by 70% current irrigated area.

These investments are simultaneously implemented given their complementarity (Ahmed and Hossain, 1990; Mu and van de Walle, 2007). The funding necessary to achieve these investments over the 5 years period is estimated at about 434[3] billion CFA (about € 660 billion), representing an annual funding of about 87[4] billion CFA (approximately € 132 million). This expense is significant and represents approximately 18% of government expenditures the reference year.

[3] 434 360 561 230 CFA
[4] 86 872 112 246 CFA

## 3. Analyzes and discussion of simulations

### 3.1. Lack of progress in the baseline scenario

The food situation described by the database (2005) is alarming for rural and urban poor. The consumption of cereal such as animal products (meat/fish) is well below standards of CILSS - 203 kg per person per year for cereals; 14kg for animal products - (Table 4). The cereal deficit is particularly important for urban poor (33%). Deficit for rural poor is more limited (14%). The deviation from the norm is even more pronounced for animal products whose deficit reached 43% and 36% respectively for the urban poor and the rural poor, pointing beyond the deficit in quantity, low quality of food.

The food situation of the poor is the result of low incomes. While the national poverty line is estimated at 83 000 FCFA in 2005, the income of urban (rural) poor are on average 32% (25%) below this threshold.

**Table 4:** Initial and baseline evolution of food consumption and income per capita

| | Grain consumption (kg) | | Meat/Fish (kg) | | Income per capita (FCFA) | | Growth rate of income per capita (%) |
|---|---|---|---|---|---|---|---|
| | 2005 | 2015 | 2005 | 2015 | 2005 | 2015 | |
| Rural Poor | 175 | 195 | 9 | 11 | 62100 | 71200 | 1.5 |
| Urban Poor | 136 | 157 | 8 | 10 | 56000 | 65600 | 1.8 |

*Source: SAM 2005 and simulations*

The weakness of poor incomes is explained by their low endowment in factors of production. They have little access to capital (20% of agricultural capital and 13% of non-agricultural capital) and are largely affected by underemployment in urban areas. The urban poor are almost deprived of all: they essentially hold their labor force but cannot find jobs. They only represent 1% of non-agricultural employment (Table 5).

The baseline simulation is parameterized to reproduce the main trends of the economy over the period 2005-2010. It is then used to reproduce the evolution of the system on 2005-2015 and to analyze the dynamics at work. The key stylized fact is that the food situation is improving only slowly. The system comes to cope with the population growth but growth in per capita consumption of cereals as animal products does not exceed 1% per year. Progress is very slow and a 10-year horizon does not enable reaching the CILLS standards which is still very far for animal products (the deficit for these products is still 29% and 21% respectively for urban and rural at the end of the simulation period). The slow growth in per capita income of the poor explains the weakness of progress on food security.

**Table 5:** Allocation of factors of Production in 2005 (%)

| | Salaried agricultural labor | Self-employment in agriculture | Non agricultural labor | Agricultural capital | Non-agricultural capital |
|---|---|---|---|---|---|
| Rural Poor | 30 | 30 | 2 | 19 | 11 |
| Urban Poor | 1 | 1 | 1 | 1 | 2 |
| Rural Non-Poor | 65 | 65 | 36 | 70 | 42 |
| Urban Non-Poor | 4 | 4 | 61 | 9 | 46 |
| Total | 100 | 100 | 100 | 100 | 100 |

*Source: SAM 2005*

### 3.2. A catastrophic situation in scenarios of agricultural productivity degradation

While the situation is already worrying for the poor in the baseline scenario, agricultural productivity degradation scenarios show high impacts on grain and meat/fish consumption (Fig. 1 and 2). In the optimistic scenario, after ten years, grain consumption levels are respectively 4% and 5% lower than in the baseline scenario (a drop from 195 kg to 186 kg for the rural poor and from 157 kg to 149 kg for the urban poor). The pessimistic scenario shows much more alarming impacts because the poor are plunged into severe food shortage: on average, the rural poor lose 12.8% of grain per capita and the urban poor 13.4% of grain per capita. Regarding meat/fish consumption, the rural and urban poor have consumption levels of around 10kg/capita/year and 9kg/capita/year respectively in the pessimistic scenario.

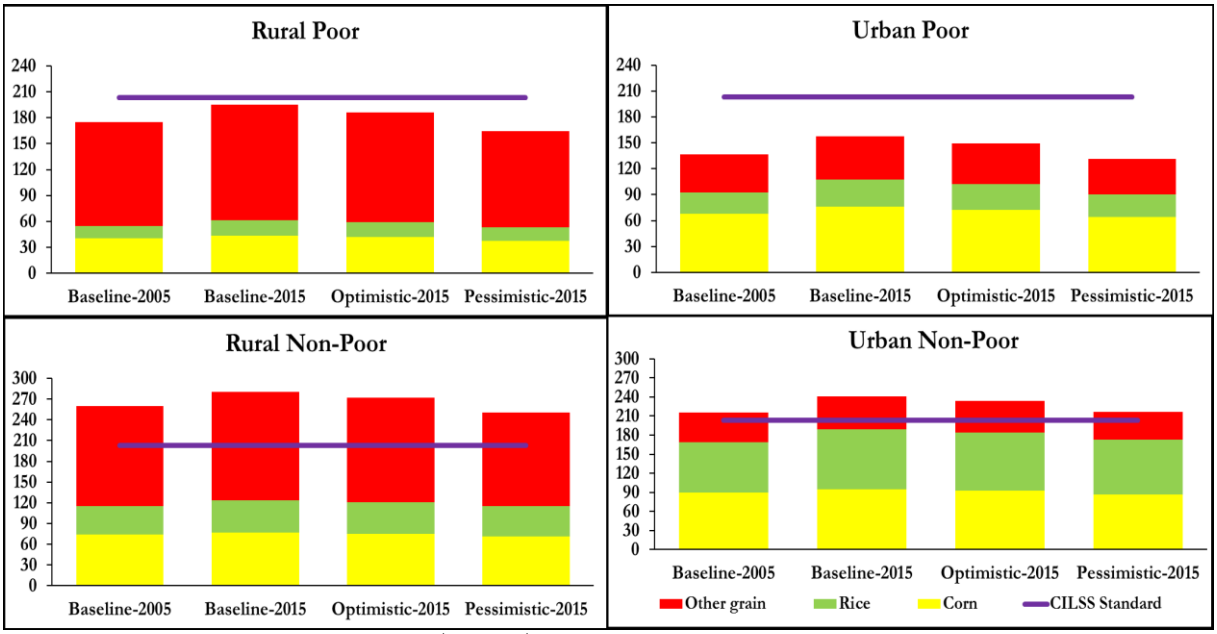


**Fig. 1:** Impact on grain Consumption (kg/person/year)

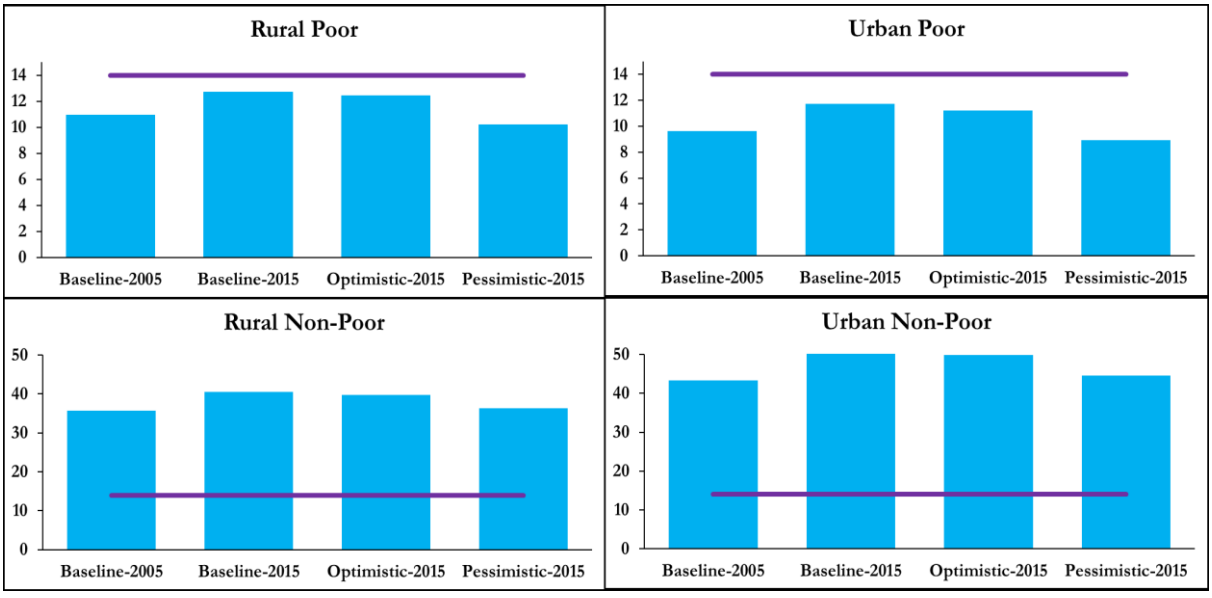


**Fig. 2:** Impact on Meat/Fish Consumption (kg/person/year)

### 3.3. Positive impacts of a public investment program on food consumption of poor

Food consumption of poor household in rural and urban areas is improving rapidly from the first years of implementation of the policy (Fig. 3 and 4). CILSS standard for grain consumption (203 kg) is reached in 2012 for rural poor while poor's grain deficit for the same year is only 18% against 25% in the reference. This norm is reached in 2015 for urban poor. Progress is particularly important for urban whose initial grain deficit reaches a third of the norm in the reference.

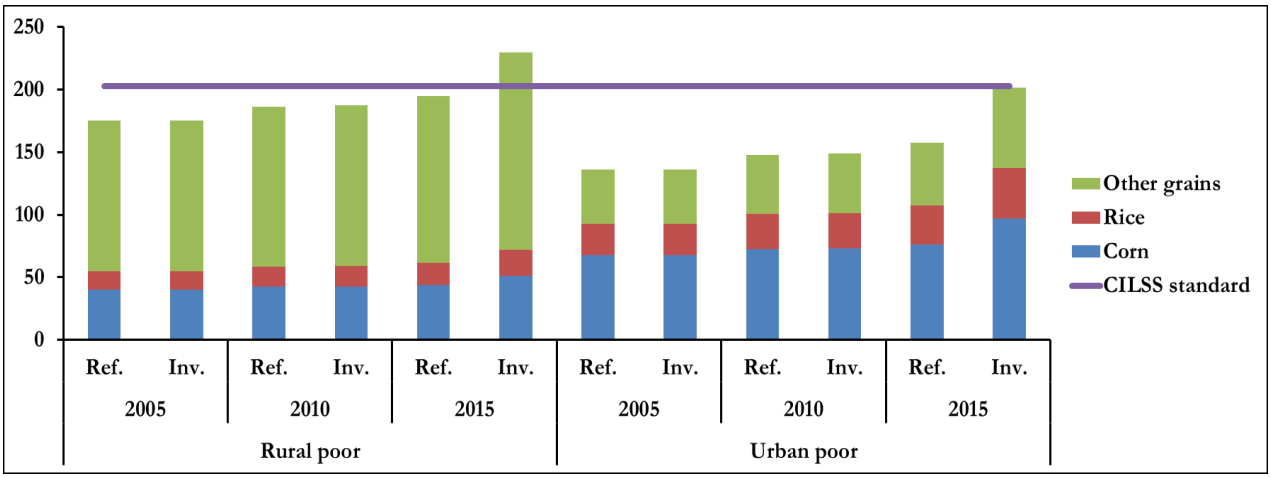


**Fig. 3:** Evolution of grain consumption of the poor (kg capita$^{-1}$ year$^{-1}$)

Similarly, for animal products (meat/fish), despite the large initial gap to the standard, the scenario with public investment enables a sufficient growth in quantities consumed of food to reach the standard of CILSS (14kg). This standard is reached by 2014 for rural poor, and by 2013 for urban poor. As in the case of grain consumption, there have been significant and fast improvements especially for urban poor. The results of investment policy are then particularly positive for the food security of poor households.

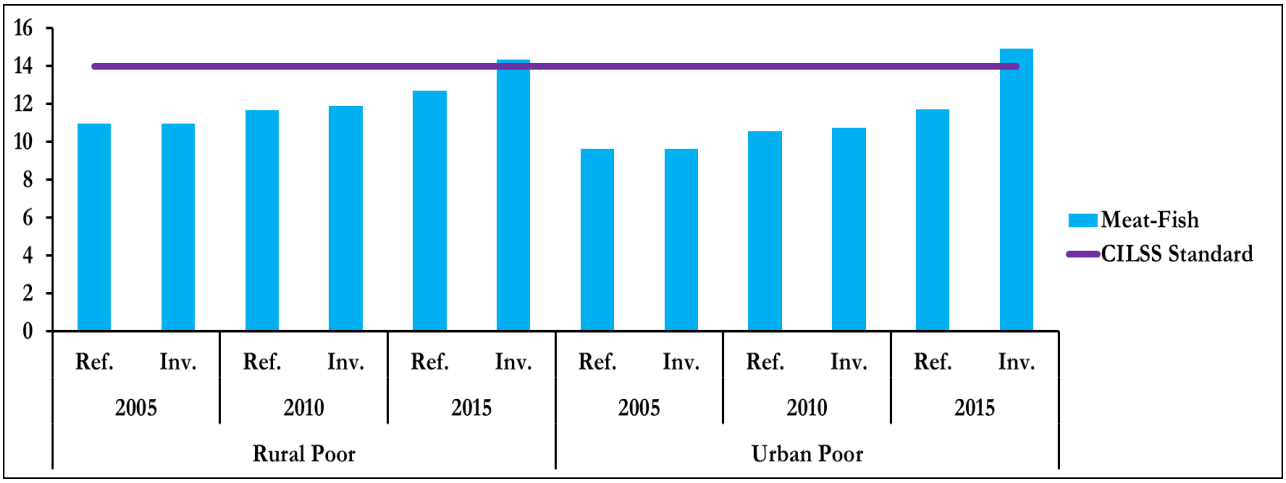


**Fig. 4:** Evolution of Meat/Fish consumption of the poor (kg capita$^{-1}$ year$^{-1}$)

### 3.4. The mechanisms at work

These different results are explained by two essential mechanisms: evolution of agricultural prices and changes in real incomes. In the scenarios of agricultural productivity degradation, one observes a drop in agricultural productions and a rise in agricultural prices (table 6). There is strong impacts on prices as for most of agricultural products, rise in prices is greater than the decline in production. A typical example is the grain sector where production at the end of period is 3% and 16% lower than in the baseline scenario while grain prices rise by 8 and 31% respectively in the optimistic and pessimistic scenario.

**Table 6:** Impacts of agricultural productivity decline on production and prices (%)

| | Deviation of production from baseline in 2015 | | Deviation of prices from baseline in 2015 | |
|---|---|---|---|---|
| | Optimistic | Pessimistic | Optimistic | Pessimistic |
| rainfall corn | -4.36 | -42.31 | 7.91 | 29.81 |
| irrigated corn | -4.39 | -18.76 | 7.91 | 29.81 |
| rainfall rice | -10.32 | -33.81 | 2.31 | 7.32 |
| irrigated rice | -12.09 | -37.72 | 2.31 | 7.32 |
| other grain | -1.94 | -7.56 | 8.38 | 32.02 |
| grain(total) | -3.03 | -15.84 | 7.99 | 30.50 |
| Vegetables | -6.36 | -21.61 | 7.96 | 31.39 |
| Groundnuts | -2.44 | -13.21 | 9.48 | 37.25 |
| Cotton | -7.99 | -14.79 | 7.45 | 29.06 |
| Fruit | -5.14 | -19.76 | 0.86 | 3.70 |
| Livestock | -4.92 | -18.62 | 3.37 | 18.10 |
| Other agricultural prod. | -9.04 | -28.03 | 4.44 | 18.84 |
| grain processing | 0.62 | 1.24 | 2.31 | 7.32 |
| Cotton processing | -11.21 | -21.19 | 4.23 | 18.57 |
| Minerals | 0.94 | 2.15 | -0.18 | -0.69 |
| Meat_Fish | -2.35 | -12.01 | 1.09 | 7.14 |
| Textile | -0.16 | -1.91 | -1.21 | -5.00 |
| Fertilizer | 0.61 | 1.07 | -0.62 | -3.18 |
| Other industrial products | 0.05 | -1.19 | -0.03 | -1.38 |
| Restoration | -1.08 | -5.48 | 0.07 | 0.66 |
| Transport | -0.79 | -4.32 | -1.52 | -5.97 |
| Other market services | -0.44 | -2.76 | -2.54 | -9.01 |
| Education | -1.18 | -6.62 | -0.15 | -0.72 |
| Health | -1.13 | -6.29 | -0.26 | -1.17 |
| 'Other non-market services | -0.95 | -5.71 | -0.28 | -1.15 |
| Trade | -0.71 | -3.75 | -3.10 | -11.20 |

The positive results in the public investment scenario are partly obtained through lower prices of agricultural products (Table 7). The decrease in food prices varies between commodities and is around 12%. This is the result of a strong growth in production made possible by the growth of the efficiency of agricultural sectors. While output grows by an average 5% per year for meat/fish and grain in the reference, it increases more rapidly in the public investment scenario (about 7% for grain and 6% for meat/fish).

**Table 7:** Impacts of Public Investment on production and prices (%)

| | Production in 2015 | | Prices in 2015 | |
|---|---|---|---|---|
| | Baseline | Investment | Baseline | Investment |
| Corn | 151 | 169 | 104 | 91 |
| Rice | 256 | 344 | 92 | 87 |
| Others grains | 157 | 171 | 101 | 88 |
| grains (total) | 163 | 186 | 101 | 88 |
| Vegetables | 150 | 180 | 103 | 90 |
| Groundnuts | 157 | 174 | 105 | 89 |
| Cotton | 62 | 84 | 101 | 88 |
| Fruits | 236 | 286 | 90 | 88 |
| Livestock | 161 | 193 | 99 | 93 |
| Other agr. products | 240 | 316 | 75 | 69 |
| Agro industry | 121 | 134 | 98 | 96 |
| Other industries | 169 | 172 | 107 | 108 |
| Services | 168 | 173 | 93 | 98 |
| Production total | 164 | 178 | 97 | 97 |

*Source: simulations*

Impact on real incomes differs according to the area of residence (rural vs urban). Surprisingly, urban dwellers are both those suffering the most from agricultural productivity degradation and those benefiting the most from public investment in agriculture (particularly urban poor). In the optimistic scenario, the income deviation from the baseline in 2015 is -1.2% and -2.0% respectively for the rural poor and non-poor, compared to -3.0% and -3.2% respectively for the urban poor and non-poor. This drop is larger in the pessimistic scenario where the income deviation from the baseline is respectively -6.4% and -8.9% for the rural poor and non-poor, compared to -11.3% and -13.3% respectively for urban poor and non-poor.

**Table 8:** Impact of agricultural productivity decline on Real Per Capita Incomes

| | | Rural Poor | Urban Poor | Rural Non Poor | Urban Non Poor |
|---|---|---|---|---|---|
| Level in 2005 | | 62101 | 56073 | 201862 | 291984 |
| 2015 income level | Reference | 71213 | 65838 | 239776 | 356325 |
| | Optimistic | 70326 | 63852 | 234912 | 344837 |
| | Pessimistic | 66621 | 58384 | 218238 | 308984 |
| Annual Growth Rate | Reference | 1.53 | 1.80 | 1.93 | 2.24 |
| | Optimistic | 1.39 | 1.45 | 1.70 | 1.87 |
| | Pessimistic | 0.78 | 0.45 | 0.87 | 0.63 |
| Deviation from baseline in 2015 | Optimistic | -1.25 | -3.02 | -2.03 | -3.22 |
| | Pessimistic | -6.45 | -11.32 | -8.98 | -13.29 |

In the investment scenario, growth in economic activity translates into incomes growth particularly for urban poor (+21% in 2015 compared to the reference). Incomes for rural poor only increase by 10% in spite of rapid growth in agricultural production because of lower prices. The decrease in the living cost (a 5% average decrease in consumer price index) is also an important part of real incomes gains observed in the public investment scenario.

**Table 9:** Impact of Public Investment on Real Per Capita Incomes and consumer price index

| | Incomes in 2015 | | CPI in 2015 | |
|---|---|---|---|---|
| | Baseline | Investment | Baseline | Investment |
| Rural Poor | 115 | 126 | 98 | 93 |
| Urban Poor | 117 | 142 | 96 | 94 |
| Rural Non-Poor | 119 | 130 | 98 | 96 |
| Urban Non-Poor | 122 | 133 | 94 | 94 |

In agricultural productivity degradation scenarios, negative impacts on income are explained by impacts on remunerations of factors of production. Urban population, whose livelihood comes mainly from non-agricultural factors face dropping of prices of non-agricultural capital (Table 10) and a rise in urban unemployment (Fig. 5), while rural population partly benefit from a rise in agricultural labor wages.

**Table 10:** Impact of agricultural productivity decline on factors of production prices

| Factor of production | Scenarios | Agriculture | Industry | Service |
|---|---|---|---|---|
| Salaried Agricultural Labor | Optimistic | 1.30 | | |
| | Pessimistic | 3.15 | | |
| Self-Employment in Agriculture | Optimistic | 3.36 | | |
| | Pessimistic | 8.27 | | |
| Agricultural Capital | Optimistic | -2.36 | | |
| | Pessimistic | -5.91 | | |
| Non Agricultural Labor | Optimistic | | -0.01 | 0.00 |
| | Pessimistic | | -0.13 | 0.00 |
| Non Agricultural Capital | Optimistic | | -2.33 | -4.27 |
| | Pessimistic | | -9.13 | -15.06 |

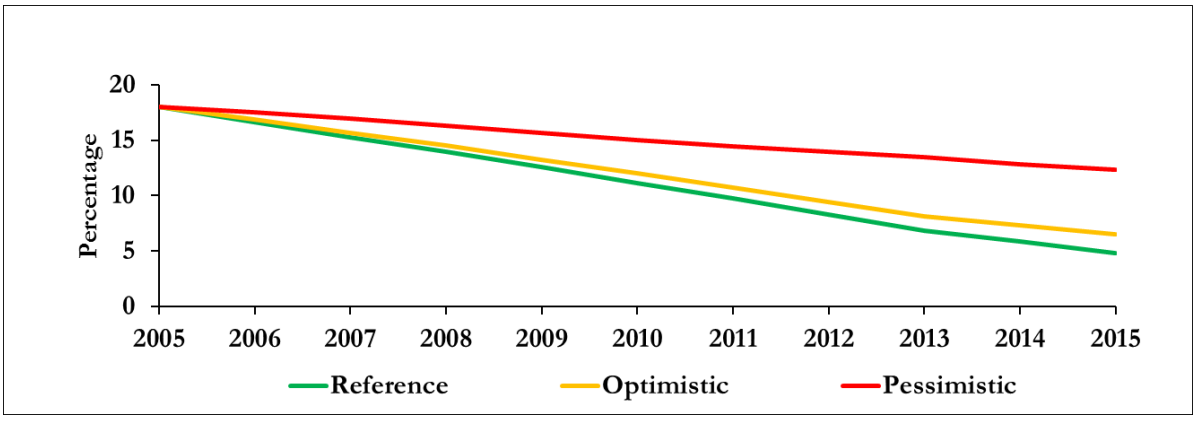


**Fig. 5:** Impact on Unemployment

The decline in non-agricultural factors of production is the consequence of a strong decline in industry and service GDPs. The added value by aggregated sector (agriculture, industry and services) shows that industry and services suffer more from the agricultural productivity decline than agriculture. The agricultural added value declines slightly despite high impacts on agricultural production levels because of the rise in domestic agricultural prices. Industrial GDP, which has a 7.1% annual growth rate in the baseline scenario, only grows by 6.8% in the optimistic scenario and by 5.6% in the pessimistic scenario. The services GDP shows the largest drop in growth rate.

While the baseline scenario indicates a growth rate of 5.48% per year, this rate drops to 4.9% in the optimistic scenario and 3.3% in the pessimistic scenario.

Two consequences of the agricultural price increase explain this evolution. First, on the supply side, the increase in agricultural prices translates into higher production costs as agricultural products are intermediate consumption goods for industry and services (food services, for example). Second, on the demand side, households' real incomes drop, which lowers demand. This is particularly true for urban households who are the main consumers of industrial goods and services.

**Table 11:** Impact of agricultural productivity decline on sectoral GDPs

| Scenarios | Agricultural GDP | | Industrial GDP | | Services GDP | |
|---|---|---|---|---|---|---|
| | Annual growth | Deviation (2015) | Annual growth | Deviation (2015) | Annual growth | Deviation (2015) |
| Baseline | 5.07 | 0.00 | 7.13 | 0.00 | 5.48 | 0.00 |
| Optimistic | 5.03 | -0.37 | 6.81 | -2.64 | 4.95 | -4.38 |
| Pessimistic | 4.69 | -3.21 | 5.59 | -12.23 | 3.34 | -16.86 |

International trade plays a critical role in food security by offsetting declines in domestic output thanks to an increase in the volume of imports and so by curbing rising domestic prices. However, its capacity to play this role highly depends both on the degree of tradability of the product in international trade and on the greater or lesser substitutability between domestic product and that of the international market. These two elements plays strongly in the armington function.

The Armington specification assumes that the price paid by the consumer is a combination of domestic and international prices weighted respectively by domestic production's share in total absorption and imports' share in total absorption (the sum of shares being equal to unit).

When a product is heavily imported, low import growth is enough to mitigate upward pressure on domestic prices (as fixed international price influence more the price paid by the consumer). In contrast, when the product is little imported, international prices have little influence over prices paid by the consumer and even strong growth can barely offset the rise in domestic prices. As we saw in table 1, only rice and fruits are the agricultural products which are highly imported while corn imports are very low and other grain imports are nearly inexistent. This explains why one observes a small increase in rice and fruits prices (2.3% and 7.3% from baseline, respectively in optimistic scenario and pessimistic scenario for rice; 0.8% and 3.7% from baseline, respectively in optimistic scenario and pessimistic scenario for fruits). In contrast, the strong growth in corn imports (+264.0% and + 5560.3% in the optimistic and pessimistic scenarios respectively) and other grain imports (+301.5% and +11868.8% in the optimistic and pessimistic scenarios respectively) does not contain the faster rise in their prices because the initial shares of imports are so low (7.9% and 29,81% in the optimistic and pessimistic scenarios respectively for corn; 8.4% and 32.0% in the optimistic and pessimistic scenarios respectively for other grain) that even double or treble the imports has no significant impacts on prices[5].

[5]Appendices give the armington function's elasticity. Several values have been tested and relatively high elasticities chosen to represent relatively homogeneous goods

**Table 12 :** Impact on grain imports and exports

| | | Imports | | | Exports | | |
|---|---|---|---|---|---|---|---|
| | | Initial shares in total absorption (%) | shares in total absorption in 2015 | Deviation from baseline in 2015 | Initial shares in total production (%) | shares in total production in 2015 | Deviation from baseline in 2015 |
| baseline | Corn | 0.36 | 0.72 | 0.00 | 0.47 | 0.28 | 0.00 |
| | Rice | 56.67 | 47.87 | 0.00 | 0.71 | 1.04 | 0.00 |
| | Other grain | 0.00 | 0.00 | 0.00 | 0.15 | 0.13 | 0.00 |
| Optimistic | Corn | 0.36 | 2.49 | 264.00 | 0.47 | 0.10 | -61.65 |
| | Rice | 56.67 | 50.32 | 5.00 | 0.71 | 0.94 | -14.40 |
| | Other grain | 0.00 | 0.01 | 301.49 | 0.15 | 0.05 | -62.65 |
| Pessimistic | Corn | 0.36 | 35.02 | 5560.32 | 0.47 | 0.01 | -97.45 |
| | Rice | 56.67 | 55.41 | 12.57 | 0.71 | 0.75 | -40.07 |
| | Other grain | 0.00 | 0.22 | 11868.82 | 0.15 | 0.00 | -96.70 |

Source: Model simulations

Rising prices in the presence of international trade is consistent with the idea that landlocked countries with poor transport infrastructures encounter many difficulties to offset a significant decline in domestic production by a strong growth in imports. While in most importing countries, a decrease in production is compensated by an increase in volume imports, in sahelian Africa, it is the consumption which is the main adjustment variable. Domestic consumption is closely linked to domestic production. Imports – almost entirely made of rice and wheat – do not absorb the difference between production and demand. This shows that the Armington function is relatively well suited to represent stylized facts of international trade in particular case of landlocked countries with poor import infrastructures.

The rise in agricultural prices is also determined by high population growth (set exogenously at 3%) which increases aggregate demand and thus exerts upward pressure on prices. However, this effect is weakened by a decrease in real per capita income growth (in productivity degradation scenarios).

It may be surprising that despite the shocks are uniformly imposed on all agricultural sub-sectors, the evolution of production is so different from one sector to another. However, the variation of production is mainly determined by the evolution of the prices. When agricultural production is dropping due to productivity decline and producers cannot increase the agricultural labor force to counteract the effect of reduced efficiency because the agricultural labor force is already fully employed (a realistic assumption in Burkina Faso where during the rainy season, the entire workforce, including children, is mobilized for farm activities) and when annual supply is growing more slowly than the population due to migration from rural areas to cities, producers will cut production more for goods whose prices increase only slightly (e.g. rice and fruits).

Beyond the positive impacts on food security and poverty, public investment in agriculture generates net gains of 1054 billion CFA or nearly twice the total cost of the public investment. GDP growth is 1.2 points higher than the baseline scenario. These figures underline the high profitability for the whole economy of a consistent and effective investment policy in rural area. It is consistent with the theory given the scarcity of capital in Burkina Faso. While improvement of productive efficiency occurs in agricultural sector, urban populations are those who benefit the most. This result is consistent with the work of Timmer (2000) on pro-poor growth enabled by improved productivity in agricultural sectors. In public investment scenario, the food situation of

urban becomes better than that of rural especially for animal products. This shows that public investment in rural areas do not always constitute a bias against urban.

## 4. Conclusion and Policy Recommendations

The results of this paper highlight the potential consequences of possible future trends in agricultural productivity. While food security status is today worrying for the poorest in Burkina-Faso, a graduate decline in agricultural productivity is likely to plunge them in food insecurity. In such a scenario agricultural prices increase which hamper the whole economic growth and decrease real incomes. These impacts are especially severe for urban dwellers because they face lower factor earnings due to the economic activity contraction and food price increases. By contrast an increase in agricultural productivity, which could be the result of a public investment in agriculture, has strong positive impacts on food security and succeed in eradicating food insecurity within five years.

In line with recommendations of international agencies such as International Food Policy Research (IFPRI) and Food and Agriculture Organization of the United Nations (FAO, 2012), the simulation results confirm the potential progress in the fight against poverty and food security expected from effective public investment in agriculture.

Obviously, the results discussed here are obtained from a stylized model that does not pretend to represent all the complex relationships of Burkina Faso's economy and its diversity. However, it represents the main characteristics of system of production and consumption and reproduces approximately the observed situation of poor households. One can therefore give some credibility to its simulation results.

The issue of the feasibility of public investment policy and its effectiveness in improving the productivity of agricultural activities are critical but not addressed in this paper, as justifying a separate study. It is clear that difficulties are numerous. Public investment requires well-functioning institutions to be effective. It is necessary to avoid the phenomena of corruption.

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**Appendices**

*Elasticities used in the CGE model*

| | Income elasticities | | | | Trade elasticities | |
|---|---|---|---|---|---|---|
| | Urban Poor | Urban Non Poor | Rural Poor | Rural Non Poor | Armington | CET |
| Corn | 0.91 | 0.33 | 0.91 | 0.33 | 17.5 | 12 |
| Rice | 1.35 | 0.77 | 1.35 | 0.77 | 5.25 | 3.6 |
| Other Cereal | 0.94 | 0.56 | 0.94 | 0.56 | 17.5 | 12 |
| Vegetables | 0.89 | 0.78 | 0.89 | 0.78 | 5.25 | 3.6 |
| Groundnuts | 0.92 | 0.82 | 0.92 | 0.82 | 17.5 | 12 |
| Cotton | | | | | 17.5 | 12 |
| Fruit | 0.445 | 0.39 | 0.445 | 0.39 | 5.25 | 3.6 |
| Livestock | 1.46 | 0.97 | 1.46 | 0.97 | 17.5 | 12 |
| Other agricultural products | 0.92 | 1.24 | 0.92 | 1.24 | 5.25 | 3.6 |
| Minerals | 0.92 | 1.24 | 0.92 | 1.24 | 1.2 | 2 |
| Meat_Fish | 1.46 | 0.97 | 1.46 | 0.97 | 17.5 | 12 |
| Textile | 0.92 | 1.24 | 0.92 | 1.24 | 1.2 | 2 |
| Fertilizer | 0.92 | 1.24 | 0.92 | 1.24 | 1.2 | 2 |
| Other industrial products | 1.02 | 1.34 | 1.02 | 1.34 | 1.2 | 2 |
| Restoration | 1.05 | 0.63 | 1.05 | 0.63 | 0.5 | 0.5 |
| Transport | 0.92 | 1.24 | 0.92 | 1.24 | 0.5 | 0.5 |
| Other market services | 0.46 | 0.62 | 0.46 | 0.62 | 0.5 | 0.5 |
| Education | 0.92 | 1.24 | 0.92 | 1.24 | 0.5 | 0.5 |
| Health | 0.92 | 1.24 | 0.92 | 1.24 | 0.5 | 0.5 |
| Other non-market services | 0.46 | 0.62 | 0.46 | 0.62 | 0.5 | 0.5 |