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Public investment in irrigation and training for an agriculture-led development:
a CGE approach for Ethiopia

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Acronyms

ADLI	Agricultural development-led industrialization
AEZ	agro ecology zone
ATVET	Agricultural Technical and Vocational Education and Training
BAU	Business As Usual
CAADP	Comprehensive Africa Agriculture Development Programme
CGE	Computable General Equilibrium
CPI	Consumer Price Index
DAs	Development Agents
EDRI	Ethiopian Development Research Institute
FTCs	Farmer Training Centres
GDP	Gross Domestic Product
GOE	Government of Ethiopia (GOE)
GTP	Growth and Transformation Plan
HICES	Household Income Consumption and Expenditure Survey
MoFED	Ministry of Finance and Economic development
NBE	National bank of Ethiopia
PASDEP	Plan for Accelerated and Sustained Development to end Poverty
PIF	Ethiopia’s Agricultural Sector Policy and Investment Framework
SAM	Social Accounting Matrix
SIM	Simulation

Abstract

Agricultural activities have been and remain key for sustained growth and pro-poor development in Ethiopia. However, the sector under utilizes its irrigation capacities as well as its abundant human resources. This paper aims at measuring the impact of public investment in small-scale irrigation and training for farmers on growth and agriculture-led development, on food security, and on poverty in Ethiopia. It is line with the current five year development strategy of the government and will give insights on the effect of selected targeted indicators. We use a dynamic Computable General Equilibrium (CGE) model to capture the outcomes of public investment shocks. Public investment is modeled in such a way that it increases the supply of skilled agricultural labor and that of irrigated land by transforming unskilled labor and non irrigated land. Two types of technologies are utilized in agriculture to produce the same crop: a more productive technology that is intensive in skilled labor and irrigated land and a less productive technology that is intensive in unskilled labor and non-irrigated land. Households have the ability to increase their endowments in labor and land. Hence, the increase in skilled labor due to public investment in the form of short term training enables households to increase the share of skilled labor they detain while reducing the share of unskilled labor. The same applies for land. Finally, the model has a poverty module using a top-down approach where changes in the CGE model are imported in the household data. The CGE model is a PEP type model and is calibrated to a SAM of Ethiopia for the fiscal year 2005/06. The poverty module uses the 2005 Household Income and Expenditure Survey.

This exercise showed that the Ethiopian government policy strategy regarding agriculture sector development has a great potential for reducing poverty and food insecurity. Simulation results show that investing in training and irrigation contributes to the effort towards achieving the MDGs. Exports expand and in particular export of cash crops that generate higher income at household and national levels. The results also show that an agriculture-led development is less likely to occur because of weak forward and backward production linkages between agriculture and manufacturing sectors where a great deal of manufacturing inputs are imported. The increment in public investment has a crowding-out effect that affects the expansion of manufacturing and services sectors which are highly intensive in private capital.

Key words: public investment, agricultural growth, food security, poverty, CGE

JEL classification: H5, D58, O4, Q16, O55

Introduction

Like many developing nations, Ethiopia's government goal is to alleviate poverty via accelerated and sustained economic growth. To attain this, the Government of Ethiopia (GOE) has designed a development strategy called Agricultural development-led industrialization (ADLI). The ADLI policy strategy has been implemented since 1993.

The objective of ADLI is to strengthen the linkages between agriculture and industry by increasing the productivity of small scale farmers, by expanding large scale private commercial farming, and by reconstructing the manufacturing sector in such a way that it can use the country's human and natural resources.

The rationale of ADLI is based on the idea that growth in agriculture will induce overall economic growth (through structural transformation) by stimulating supply and demand. On the demand side, expansion in agricultural activities would increase demand for industrial products (inputs and consumer goods) produced by domestic industries. On the supply side, the agriculture sector would supply food to domestic market, raw materials to industries and export products (Diao et al, 2007). In the ADLI framework the "key assertion is that the primary driver of demand for industrial output will be domestic, rather than foreign demand, based on first initiating growth in agriculture." (Dercon and Zeitlin 2009). This reflects the view that the process of industrialization should build on domestic inputs.

The implementation of ADLI has been supported by an important public investment program geared towards the agricultural sector. The trend of public spending in Ethiopia reflects a tremendous increase reaching 22.1% of total capital expenditure and 9.2 % of total recurrent expenditure in EFY 2009/10. Public spending has soared since the EFY 2006/07 which marks the beginning of the five-year development strategy, the Plan for Accelerated and Sustained Development to end Poverty (PASDEP). The PASDEP was designed to allow the GOE meet the MDGs and it upgrades and builds upon the ADLI strategy. Accordingly, it targets poverty-oriented sectors namely: education, health, agriculture and rural development and roads.

While agriculture is the backbone of the Ethiopian economy, it is characterized by low performance in terms of production and productivity. Productivity gains are to a large extent due to land expansion and favorable climate. Despite unprecedented economic growth reported over the past consecutive years, Ethiopia remains one of the most food insecure countries in the world (WDI, 2009). Although poverty is decreasing reaching 29.2% in 2009/10 fiscal year from 38.7% in 2004/05 (GTP, 2011), inflation and in particular food prices have been soaring putting in distress the livelihoods of the populations in particular those just above the poverty line. Given these facts, agricultural policy is shifting away from safety net program to focus on strategies that promote long term productivity and production. Public finance is also planned to shift accordingly.

In light of this, this paper aims at measuring the impact of public investment in small-scale irrigation and training for farmers on growth and agriculture-led development, on food security, and poverty in Ethiopia.

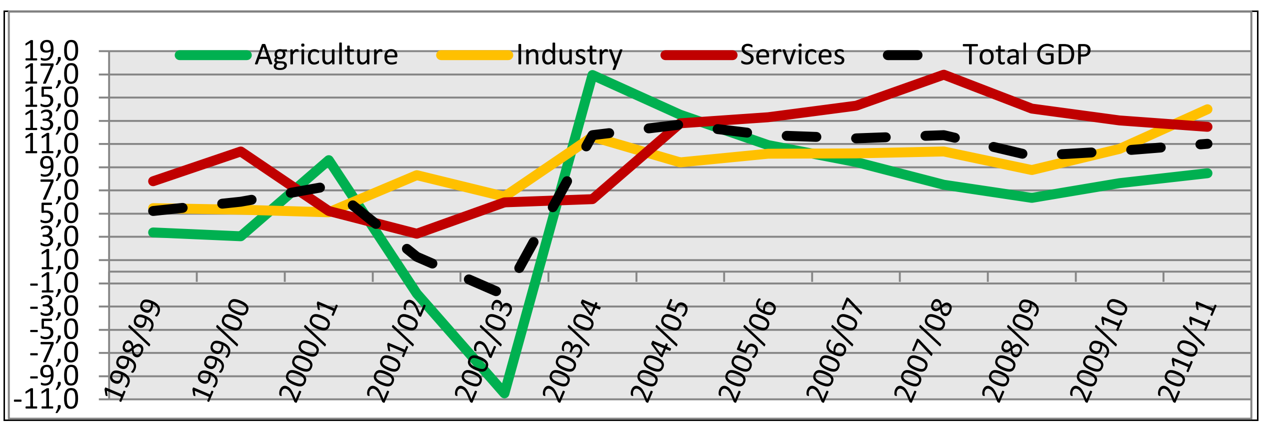
Stylized facts of the Ethiopian economy

Performance of the economy

The Ethiopian economy has been performing at a high growth rate since 2003/04. Real GDP has grown by 11.9% and 10.5% in 2003/04 and 2004/05 respectively. This has been sustained during the last five years too; overall real GDP has grown rapidly at an average of 11% per annum during the PASDEP period (2005/06-2009/10) (See Table 1. and Figure 1. below.).

During the last five years all sectors of the economy registered a significant growth. However the service sector grows tremendously, which makes the sector play the major role towards enabling the accelerated overall economic growth. Agriculture, industry and service sectors have registered an average annual growth rate of 8.4%, 10% and 14.6%, respectively.

Figure 1. Trend in GDP (at basic prices) Growth by Economic Sector (%)

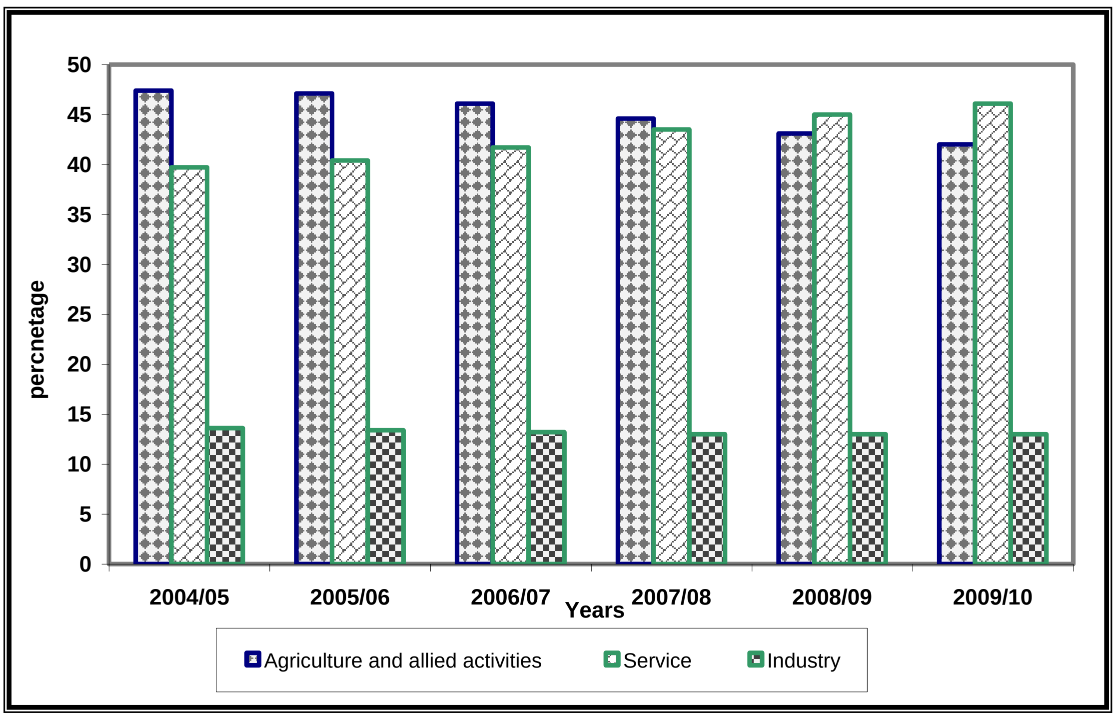


Source: Authors computation based on data from Ministry of Finance and Economic Development

The contribution (percentage share) of each of the three sectors (agriculture, industry and service) to overall GDP in 2009/10 was 41.6%, 12.9% and 45.5%, respectively (See Figure 2). In terms of structural change the decline in the agricultural sector's share of GDP was taken up by the service sector. Services achieved a higher share of GDP which makes the sector the major contributor to the country's GDP unlike the agrarian economy.

With the construction, real estate, retail and wholesale trade, transportation and financial services being the major drivers, the service sector is becoming a significant source of the growth and has benefited from increased public investment (Figure 2 & 3). Government investment that has peaked during the period in nominal terms is one major contributor to service sector growth. The services sector is also emerging as a source for exports (tourism and air transport).

Figure 2. Percentage share of GDP by Economic Sector



Source: Authors computation based on data from Ministry of Finance and Economic Development

On the demand side, GDP growth is attributable to both consumption and investment increases. Significant public investments have been made to support the expansion of economic and social infrastructures, primarily roads, telecommunication infrastructures, hydroelectric dams, and health and education facilities.

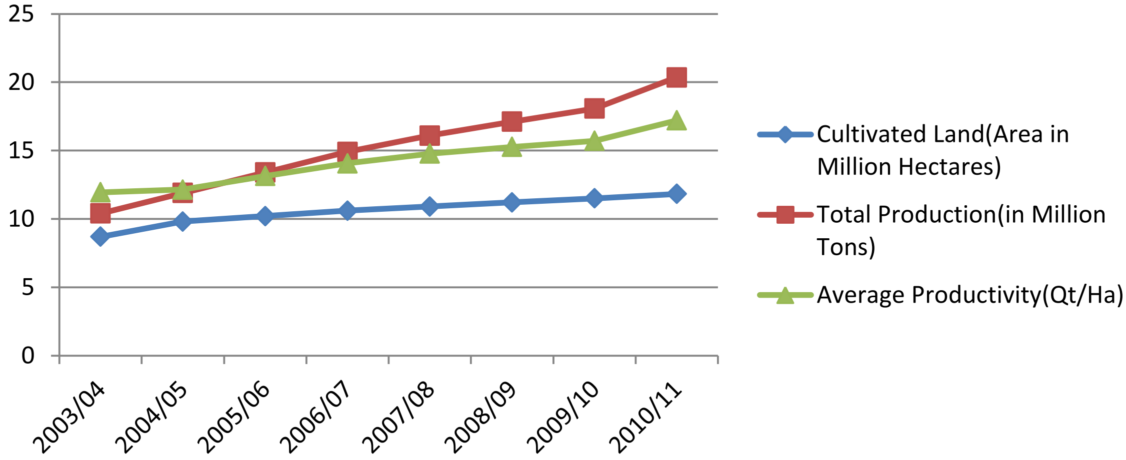
Agriculture sector, its role and performance

Agriculture is the back bone of the Ethiopian economy. Looking at the sector's role to the economy, the agricultural sector contributes up to 41.6 % of GDP and 82 % of export (MoFED and NBE). Even if it remains the major sector to the economy regarding export earnings, there has been increased diversification in the export volume in recent years. Coffee, which contributed 70% of export earnings some decade ago, now contributes less than 40%, while flower, leather, oilseeds and pulses, gold and chathave become increasingly more important, each contributing about USD 50 million per year. Despite the change in role, the diversification remains within the sector.

Even though, agriculture is the backbone of the Ethiopian economy, its production and productivity have long been unsatisfactory. The overall GDP is highly influenced by trends in the agricultural sector. The rate of growth of agricultural production has constantly been lagging behind the rate of growth of the GDP and the rate of growth of population. The country has not for the large part been able to produce enough food to feed its population because of the poor performance of the agricultural sector. Ethiopian agriculture sector is characterized by backward technology and dominance of small holder farmers with subsistence mode of production.

Despite the implementation of ADLI for the last 18 years, the rate of return of the agricultural sector remains relatively low and production is growing unsatisfactorily and it is still heavily dependent on weather conditions. Average productivity was 12 quintal per hectare of land before the PASDEP period and it showed a slower improvement and reached 15.7 at the end of PASDEP (2009/10). In fact, with a special attention of the government it exhibited faster progress during the first year of the GTP. The productivity gains are to a large extent due to the expansion in cultivated are and favorable climate with a minimal role of improved technology. Area cultivated is more or less increasing at a constant rate through the period from 2004/05 to 2010/11. Total harvest has been increasing at a slightly decreasing rate during 2003/04 – 2009/10. The growth rate showed faster pace during 2010/11.

Figure 3. Performance of Ethiopian agriculture sector (2003/04-2010/11)

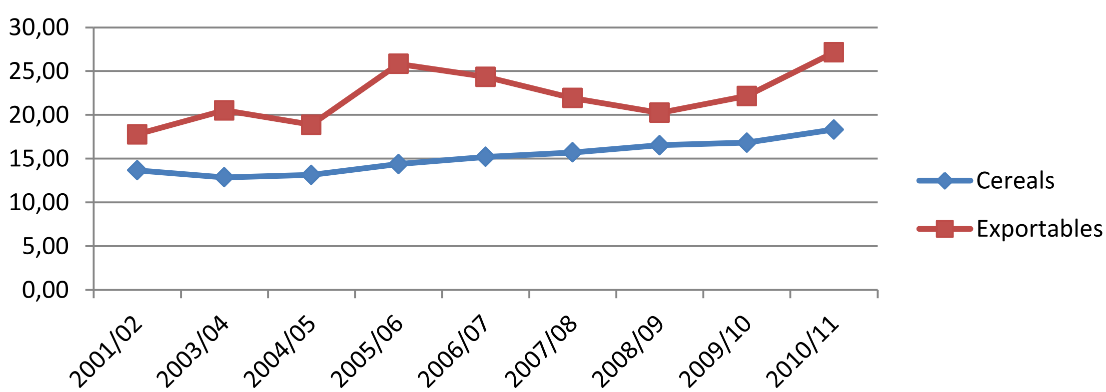


Source: CSA data with authors' computation

Regarding poverty, the food poverty head count decreased from 42% in 1999/00 to 38% in 2004/05 and brought down to 33.6% 2010/11 (MoFED, 2012). The per capita grain production increased from below 1.5 quintal in 2003/04 to 2.13 in 2007/08.

When we look at detailed performance of crop types exportable crops are performing well as compared to cereals. Average productivity of exportables has been higher for all the years displayed in figure 4. Cereals' productivity has been increasing more or less at a constant rate but that of exportables decreased from 2005/06 to 2008/09 and has been increasing at a faster rate than that of cereals especially in the recent years. This shows that besides staple foods exportables need government's attention for the economy benefit more from their enormous potential.

Figure 4. Average productivity by crop type



Source: Authors' computation based on data from CSA, Agriculture sample surveys

The main reasons for the slower growth of production and productivity of the sector could generally be put as follows:

i. Limited access to modern agricultural inputs (chemical fertilizers, insecticides, pesticides, high yielding seeds, farm machinery) and advanced methods of farming.

ii. Limited extension services and also lack of proper know-how of agro-technical means, which could increase productivity.

iii. Inadequate and underdeveloped economic infrastructures including transportation and communication facilities have been serious impediments to the development of the sector.

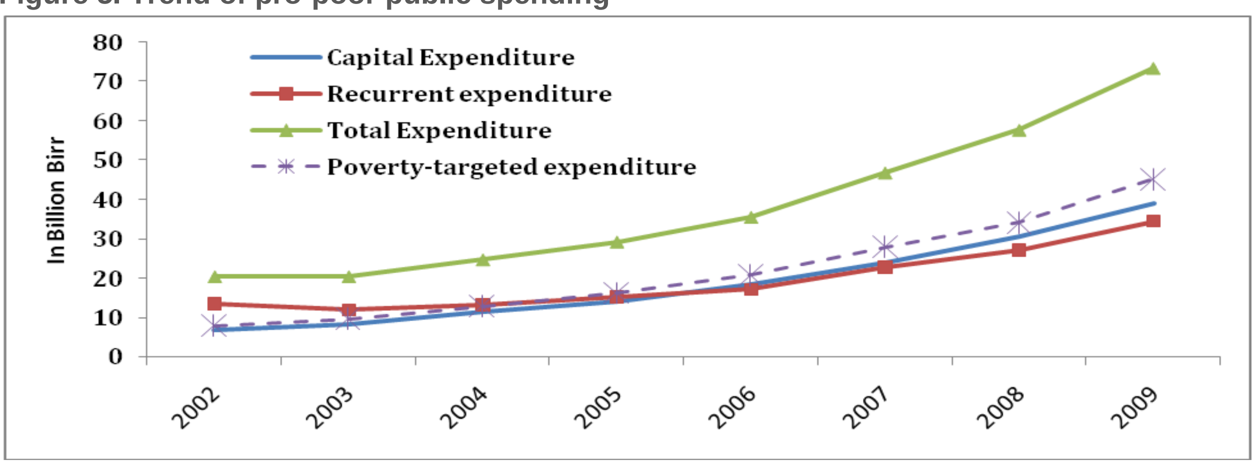
iv. Lack of proper marketing and financial facilities and services.

v. Shortage of trained manpower in the rural areas and very low level of utilization of the irrigation potential of the country.

Public finance in the agriculture sector

In line with the PASDEP, poverty-oriented sectors accounted for 46% of current and over 80% of capital expenditure in EFY 2007/08 (Figure 1). Poverty targeted expenditure constituted 46.6 % of the recurrent expenditure in 2007/08 showing an increase of 36.3 % compared to the previous fiscal year; and 80.5 % of the capital expenditure, witnessing a 33.3 % increase compared to fiscal year 2006/07 (MoFED, 2009). Investment in agriculture and food security and education sector took the lion's share. For the last four years, poverty-oriented public spending has amounted more than 60 % of public spending.

Figure 5. Trend of pro-poor public spending



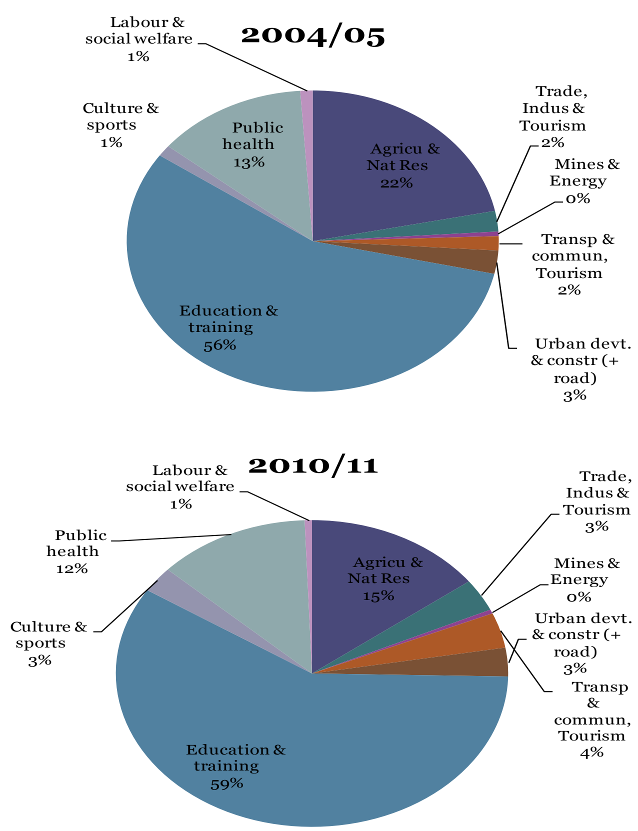
Source: MOFED Annual Progress Report 2007/08

When considering all economic and social sectors, the Fiscal Year 2006/07 marks a boom in capital expenditure in the services sector, mainly in road construction, transport and communication, urban development and housing (Figure 2).

The agriculture sector benefits from a significant amount of public investments. The agriculture sector budget which was Birr 6.8 Billion (including both recurrent and capital) by 2008/09 is expected to be Birr 7.3 Billion by 2010/11 and Birr 14.7 Billion by 2014/15, and Birr 29.5 Billion by 2020. This means it is expected to more than tripled by 2020. In line with ADLI the agriculture sector budget ratio from GDP is to increase at a decreasing rate during the next 10 years.

Sectoral shares of total recurrent expenditure are provided in Figure 5 below. It is clearly visible that education is getting the larger share of government recurrent expenditure for both years, agriculture and natural resources' share of the budget declined from 22% in 2004/05 to 17% in 2020/11. However, shares of almost all the other sectors have not been significantly changed.

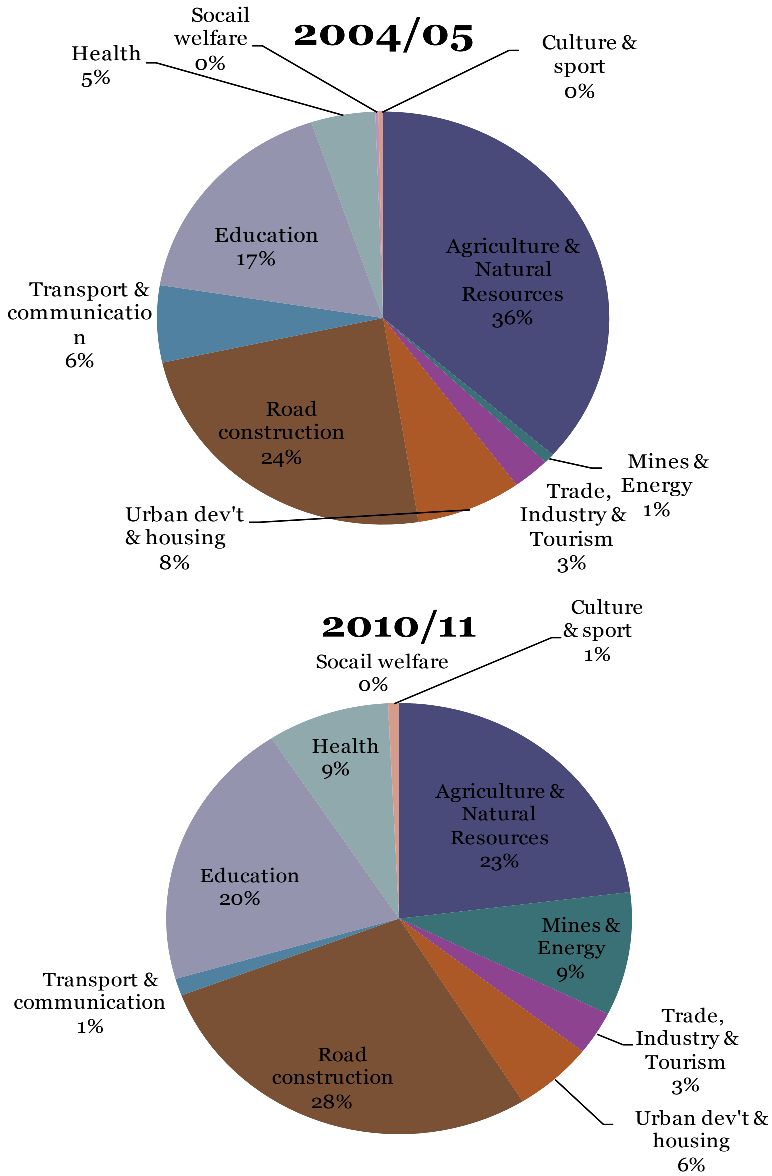
Figure 6. Share in recurrent expenditure



Source: Authors' computation NBE Annual Reports

There has been a boom in public capital expenditure since the early 2000's. Besides, there are changes in the sectoral shares. Agriculture got the highest share in 2004/05 but road construction takes over the highest share in 2010/11. The road construction sector is believed to be one of the key areas that could contribute to agricultural development through a better access to markets and lower transaction and transport costs. Agriculture and natural resources still get significant amount of the budget. The other sector which gets greater attention is education whose share of capital investment increased from 17% 2004/05 to 20% in 2010/11.

Figure 7. Share in Capital Expenditure



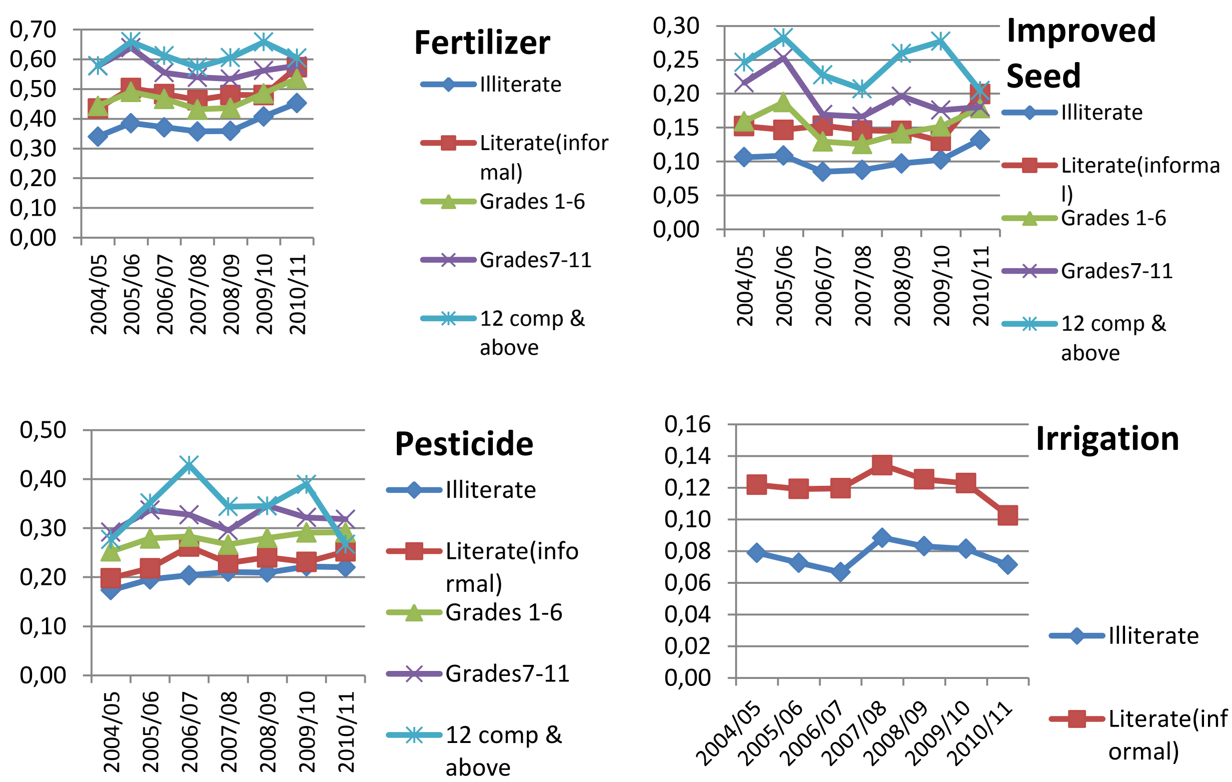
Source: Authors' computation from NBE Annual Reports

When allocating the capital budget for agriculture and natural resources, proposed budget estimates for the next 10 years (2010-2020) is to allocate 31, 48, and 21 percent of the capital budget for natural resources, agricultural development (farm income improvement pillar), and agricultural marketing interventions, respectively.

Education and adoption of improved technologies

Theoretically and empirically it has a strong logical ground that the more educated the farmers are, the more likely they are to adopt improved technology. Actually this holds true for Ethiopia looking at the data from 2004/05 to 2010/11. For adoption of fertilizer, improved seed and pesticide farmers who got education up to 12 and above are adopting the best and the next best educated, grades 7-12, are adopting the next best. Illiterate farmers are more attached to back ward technology and are more-off risk- averse, so that their adoption of improved technology is poor as compared to the other educated farmers. The same is true for adoption of irrigation; the literate farmers are adopting irrigation more than the illiterate farmers.

Figure 8 - Adoption of improved technology by education level



Source: Authors' computation based on Agriculture Sample Survey data (CSA)

Currently, the government is giving more emphasis to irrigation by way of enhancing the food security situation in the country. Irrigation development measures were taken to put in place small, medium and large scale irrigation schemes. Efforts are being made to involve farmers progressively in various aspects of management of small-scale irrigation systems, starting from planning, implementation and management aspects, particularly, in water distribution and operation and maintenance to improve the performance of irrigated agriculture.

It was planned to develop 58,750 hectares by establishing 470,000 water harvesting schemes and small irrigation systems; by the end of the plan period 122,430 hectares of land were developed by these means. During the PASDEP period, 853,000 hectares of land serviced by small scale irrigation systems was developed well in excess of the target of 487,000 ha (MoFED, 2010).

Towards increasing production and productivity, the other major strategy gives due emphasis is agricultural extension service. During PASDEP 52,023 graduates had completed training in the fields of plant, animal and natural resource sciences and cooperatives development to support the agricultural extension services, at agricultural and vocational training colleges. In the same period government managed to increase the number of minimum package trainees to 12.7 million. Household family package trainees increased to 5.4 million, which is higher than the planned target by 12.5% and the number of farmers training centers increased by 9,265. The necessary equipments were also supplied for these newly built training centers. With these, it is clear how much government pays attention to farmers' education and towards educating extension workers.

Framework for examining the effect of public spending in training and irrigation

Literature review

Ethiopia is following the standard pattern of agriculture-led economic growth. The country has formally adopted Agriculture Development Led Industrialization (ADLI) as a development strategy in 1994, with the aim of investing in agricultural productivity in order to stimulate farm output and incomes. This strategy has been justified because agriculture is the largest sector in terms of output and, particularly, employment and exports; the bulk of the poor is agrarian in rural areas. There exists substantial potential to raise agricultural productivity via the widespread introduction of modern technology (MoFED, 2002). In line with this the GoE is spending a significant public resources to come up with more productive and developed agricultural sector. It prioritizes larger coverage of farmers' training and irrigation among others. These are the major factors in most of the successful countries in agricultural growth. The success storiy of China's food self sufficiency in the 1960s and 1970s, was attributed to a massive investment in irrigation (Huang et al., 2005; and Huang et al., 2006) implying that irrigation plays an important role in poverty reduction. According to a study by M. Fanadoz (2012)_in South Africa it is revealed that small irrigation schemes (SIS) have greater positive impact on economic growth and poverty reduction but this can completely be missed unless government takes SIS revitalization measures trough capacity building in basic crop and irrigation management practices, and strengthening institutional and organizational arrangements.

Regarding economic benefits of education, Croppenstedt et.al (1998), argue that literacy is a good tool that creates awareness and capacity for farmers to adopt modern inputs and improved technologies. Education may enhance farm productivity directly by improving the quality of labour, by increasing the ability to adjust to disequilibria, and through its effect upon the propensity to successfully adopt innovations. Education is thought to be most important to farm production in a rapidly changing technological or economic environment (Shultz 1964; 1975). According to a study by Fan et al (1999) in India public spending on rural education among others has negative and statistically significant effects on rural poverty. Using similar methodology, public expenditure on rural education in China has the largest impact on rural poverty (Fan et al, 2002).

However, when it comes to the impact of general public investment on economic growth we find contrasting results from previous studies. According to a study by Easterly and Rebelo (1993) public investment by central government had a positive and statistically significant effect on economic growth. Devarajan et al. (1996) challenged this finding. Whith an assumption which states each expenditure category can be increased only at the expense of others, they found that public capital expenditure had a negative, and statistically significant, effect on growth.

As it is clearly put in the ADLI strategy of the GoE and implemented in the PASDEP and also in the current GTP midterm plans, agriculture development is supposed to drive the non-agriculture sector in particular and the overall economy in general to development and come up with reduction in poverty and food insecurity. However, there is a debate on whether Ethiopia should continue on its current agricultural development led industrialization strategy (ADLI) or if it should make adjustments to its growth approach.

On the one hand, X. Diao et al (2007) argued that the emphasis of ADLI and PASDEP on agricultural growth is, in principle, warranted. And the results of the paper imply that agricultural growth induces higher overall growth than non-agricultural growth. It also leads to faster poverty reduction since it generates proportionately more income for farm households who represent the bulk of the poor. Decomposition of these effects also reveals that consumption linkages are much stronger than production linkages. Early work in India during the Green Revolution indicated that higher-income small farmers spent about half of their incremental farm income on non-farm goods and services as well as another third on perishable agricultural commodities (Mellor and Lele 1971). Thus, consumption linkages from growing farm income can induce sizable second rounds of rural growth via increased consumer demand for non-agricultural goods and services as well as perishable, high-value farm commodities. On the other hand, the results also clearly show that exclusive focus on agriculture (or insufficient attention to non-agriculture) is counter-productive. Non-agricultural sectors have to grow in order to match growing supply of agricultural products and increasing demand for non-agricultural products. Otherwise, falling relative prices of agricultural products may dampen the realized gains in growth and poverty reduction.

Besides, Mellor and Dorosh (2009) argue that “A high rate of agricultural growth has far-reaching positive implications for economic development of low-income countries in terms of increasing employment and accelerating poverty reduction. High agricultural growth also helps avoid the creation of mega-cities with large slum populations. In order to achieve this rapid agricultural growth with positive economy-wide linkages, however, it is necessary to engage “middle farmers”, large enough to adopt new technologies and produce significant marketed surpluses, but small and numerous enough to have spending patterns that drive a vibrant rural non-farm sector. Finally, public and private investments in road, electricity and telecommunications are also needed to reduce marketing costs and enable growth in rural market towns and secondary cities.” Their argument noted that for agriculture to be driver of the economy farmers are required to be “middle farmers”, unlike Ethiopia’s concentration of small scale farmers with less capacity of new technology adoption. They have also noted that Agricultural development led industrialization requires high levels of government spending. In line with their argument, Ethiopia’s government has been allocating high proportion of public resources towards agriculture through its pro-poor spending strategy.

On the other hand, Dercon and Zeitlin (2009) noted that with modest consumption linkages agricultural innovation will not suffice to drive growth in industry. “More positively, the increasing frequency of trade 'in tasks' suggests that it may not be necessary for Ethiopian agriculture to be oriented toward the supply of raw materials for industry, nor for all industrial energies to focus on the processing of domestic raw materials. However, the most effective policies to stimulate growth may be those that strengthen domestic and international linkages," Dercon and Zeitlin (2009).

In light of this, the paper attempts to test empirically the outcomes and sustainability of ADLI policy through an increase in public investment keeping in mind the main objectives of the ADLI-PASDEP-GTP policy: food self-sufficiency, rapid and sustainable growth, and poverty reduction. The following section presents the policy framework that guides our research.

Policy framework

The choice to measure the impact of public investment in irrigation and training is inspired by the five-year national development plan, the Growth and Transformation Plan (GTP). The GTP has the overall objective of eradicating poverty, improving citizens' livelihood and transforming Ethiopia into a middle income country. It intends to attain this through a sustained, rapid and equitable economic growth and by maintaining agriculture as the major source of economic growth.

An agriculture-led development requires investment in a country's capacity to market its products but supply side constraints also need to be addressed. Accordingly, boosting productivity through the use of improved seeds, fertilizer, small and medium scale irrigation, investment in human capital, access to credit, as well as switching to higher value crops and multi-cropping are the major areas of intervention in Ethiopia. Our focus is on irrigation and farmers' training in line with the GTP. Extension and training programs are designed to enhance farmers' capacity to use water resources and other inputs efficiently. The government plans to reproduce the results obtained by model farmers in a larger scale. Irrigation will have the impact of increasing land productivity and output while training will increase labor productivity for the same level of other inputs but also through the use of improved technologies.

The two Strategies outlined in the GTP that apply to our research are:

- Scaling up best practices of model small holder farmers to increase productivity and production which is simulated through the increase in public investment for training farmers;
- Intensify the use of water and natural resources with priority to small scale irrigation schemes simulated through public investment for irrigation.

Ethiopia's Agricultural Sector Policy and Investment Framework (PIF) 2010-2020 is another document utilized as a reference to design the scenarios. The PIF is a 10-year road map for development that identifies priority areas for investment and estimates the financing needs to be provided by Government and its development partners. According to the PIF, increasing productivity in smallholder agriculture is Government's top priority, recognizing the importance of the smallholder sub-sector, the high prevalence of rural poverty and the large productivity gap. The document explains that in the coming years the key challenge will be to re-balance policy and investments to pursue sustainable productivity and profitability objectives, whilst executing a carefully controlled phasing down strategy of social safety-net activities. Regarding the investment framework, government is expected to continue its strong commitment to financing agriculture and rural development over the next decade, and the expectation of continued strong economic growth will increase the agricultural sector budget from around USD 0.7 billion in 2010/11 to as much as USD 1.7 billion per annum by the end of the PIF period. Additional investments of around USD 6.2 million are also foreseen.

The document sets out five basic directions for agricultural development of which the first two are:

- Alabor intensive strategy, which sees the mobilization of under-utilized and un-productive rural labor as a key driver of growth, rather than capital-intensive approaches. It envisages high levels of training and technology adoption in order to boost agricultural productivity without drawing heavily on the country's scarce capital resources; and
- Proper utilization of agricultural land, by guaranteeing the availability of land to people who seek to make a living out of land, and assisting them to utilize it productively on a sustainable basis through irrigation, multi-cropping and diversified production.

Smallholder agriculture is expected to remain the principal source of agricultural growth. Increasing smallholder productivity and production is the main thrust of the plan and is planned to be achieved in three major ways:

- by scaling up best practices used by leading farmers whose productivity is 2-3 times higher than the average
- by improving the management of natural resources with a focus on improving water utilizationand the expansion of irrigation
- by encouraging farmers to switch to high value products in order to increase their cash incomes, with complementary investments in market and infrastructure development.

The document indicates that these initiatives will be supported by farmers training and measures to improve access to agricultural inputs and product markets using cooperatives as a delivery mechanism. It recognizes that the agricultural extension system is a major element of the agricultural and rural development strategy where core institutions are the Agricultural Technical and Vocational Education and Training (ATVET) centres and the Farmer Training Centres (FTCs). These institutions are currently functioning to produce, as well as use, the human capital that is embodied in Development Agents (DAs). ATVETs train DAs and the DAs in turn use FTCs to train farmers.

Under the agricultural productivity strategic objective, agricultural productivity (value outputs/value inputs) per crop and livestock unit is expected to increase by 4% annually. Under the strategic objective that aims to reduce degradation and improve productivity of natural resources, an 8% annual increase of arable land is expected to be irrigated as well as a 5% annual increase in crop yield per unit of water used due to water conservation and water use efficiency interventions.

With regard to funding of this agricultural development strategy, between 13 and 17 per cent of government expenditure (equivalent to over five per cent of GDP) has been channeled towards agriculture (including natural resource management) in recent years. About 60 per cent of agricultural investments are funded from the Government budget, 30 per cent from grants, and 10 per cent from concessional loans. More than half of this expenditure supports chronically food insecure households through safety net programs. Investments are also directed towards expanding the extension system, irrigation development, and improving rural commercialization and agro-processing. In the coming years the objective is to re-balance policy and investments to pursue sustainable productivity and profitability objectives, whilst executing a carefully controlled phasing down strategy of social safety-net activities.

Based on the assumption that the economy will continue to grow at 10% over the ten years of the PIF, an investment framework was projected under which there would be a gradual increase in the funds allocated to the budget for agriculture and rural development from 7.0% of GDP in 2008/09 to 7.5% by the end of the PIF period. On this basis, 38.2% of the budget would be allocated to irrigation development at the end of the PIF from 34 million USD in the first period to 5,921 million USD the last year of the PIF. About 8% of the budget would be allocated to agricultural research, extension and seeds at the end of the PIF from 8 million USD in the first period to 1,179 million USD the last year of the PIF; 80% of the total budget being allocated to capital expenditure.

Agricultural activities have been and remain key sectors for sustained growth and pro-poor development. The sector underutilizes its irrigation capacities as well as its abundant human resources. There is therefore room for remarkable progress in the sector. The following section presents the data used to calibrate our CGE model.

The SAM (Social Accounting Matrix)

The CGE model used in this analysis is calibrated on a social accounting matrix (SAM) of Ethiopia which was built by the Ethiopian Development Research Institute (EDRI) based on 2005/2006 data. The EDRI 2005/2006 SAM distinguishes 47 activities (14 agricultural, 20 manufacturing and 13 services) producing 69 commodities (25 agricultural, 30 manufacturing and 14 services). There are 5 primary factors of production (agriculture labor, non agriculture labor, agriculture capital-land, livestock capital, non agriculture capital). Non agriculture labor is also disaggregated by occupational category (administrative, professional, unskilled and skilled). There are 4 aggregate household groups: rural and urban, and by poverty level: poor and non poor that become 6. The SAM has 17 tax accounts as well as aggregate accounts for trade margins, transport margins, government, investment, and the rest of the world.

The SAM required aggregation and disaggregation work to fit needs of the study and the modeling requirements. In addition, the SAM has been updated until 2009/10 to reflect to the extent possible the macroeconomic situation during that period. The value of the GDP for 2009/10 at constant market price was taken as a reference. Information was taken from the National Bank of Ethiopia (NBE) and the Ministry of Finance and Economic Development (MOFED) data. The following were taken as benchmarks to update the SAM using their shares in the 2009/10 GDP:

- Agricultural GDP: 42%
- Manufacturing GDP: 13%
- Imports: 33%
- Exports: 13.6%
- Gross fixed capital formation: 22.3%
- Private final consumption: 86.1%
- Tax revenue: 11.3%
- Current net income and transfers: 8.3%
- Current account Balance: 30%

To update the SAM, the first step consisted in expressing all the values in the sum as a share of the total of rows and columns. The next step consisted in scaling up the GDP at purchaser price in the SAM to its value in 2009/10 as this is the only reference utilized to update the indicators above. The third step consisted in incorporating one by one the above indicators by introducing them through constraining equations. The optimization process is run at each step making sure that there is a solution and the new SAM is balanced.

Furthermore, agricultural labor and land have been disaggregated using data from the 2011 Agriculture Sample Survey. Agricultural labor was disaggregated by skill between skilled and unskilled labor. Skill was defined using five proxies: use of improved seeds, use of fertilizer, use of irrigation, use of extension services and literacy rates. To disaggregate land between irrigated and non-irrigated land types, the same survey was utilized combined with information from the Ethiopia's Agricultural Sector Policy and Investment Framework (PIF) 2010-2020. All the data shows that a very small share of agricultural land is irrigated although the potential is high for irrigation practices. Similarly, the share of skilled labor is very low.

The following presents major characteristics of the 2009/10 SAM.

Value added is labor-intensive in agricultural sectors (75.2%) while manufacturing and services sectors are intensive in capital (61.9% and 77.8%). Agricultural labor and land are only employed in agricultural production. Non agricultural capital is employed by manufacturing and services sectors and livestock capital is only utilized in agricultural production. Overall value added is intensive in labor (48.5%) followed by capital (44.9%).

Table 1-Structure of value added

	Agriculture	Manufacturing	Services	Total
Agricultural labor	75.2%	0.0%	0.0%	34.1%
Non agricultural labor	0.1%	38.1%	22.2%	14.4%
Land	14.4%	0.0%	0.0%	6.5%
Capital	10.2%	61.9%	77.8%	44.9%
Total	100%	100%	100%	100%
	Agriculture	**Manufacturing**	**Services**	**Total**
Agricultural labor	100.0%	0.0%	0.0%	100.0%
Non agricultural labor	0.5%	37.0%	62.5%	100.0%
Land	100.0%	0.0%	0.0%	100.0%
Capital	10.3%	19.3%	70.4%	100.0%
Total	45.3%	14.0%	40.6%	100.0%

Within agricultural activities production of cereal crops, pulses, oil seeds, vegetable and fruits, and forestry and fishery are relatively more labor intensive with over 82% of the value added while production of cash crops (cash crops except coffee), coffee, enset and livestock farming are relatively less intensive in labor and more intensive in land, 42% of the value added.

One third of agricultural labor is concentrated on cereal crop sectors as well as 35% of land which produce 30.8% of agricultural output. These sectors are important as they are the key to ensuring food security and price of food. Cash crops concentrate 29.5% of agricultural labor and use 65% of land producing 31.6% of agricultural output. These sectors play an important role are most of these products are destined for the export market. The livestock sector is important as it concentrates alone 27.6% of agricultural labor, 32.2% of non-agricultural labor and 91.7% of agricultural capital producing 27.3% of output in the agricultural sector. It is the sector that finished and semi-finished goods destined to be exported such as meat and meat products and leather.

The following table presents the disaggregation of agricultural labor by skill and land by use of irrigation or not.

Table 2 - Disaggregation of agricultural labor by skill and land by use

	Teff	Barley	Wheat	Maize	Sorghum	Pulses	Vegetables and fruit	Oil seeds	Cash crops	Enset	Crops	Coffee	Livestock farming	Forestry & fishing	Total
Skilled Agri. labor	18.9	18.9	21.5	20.5	15.6	15.8	20.7	16.4	16.7	15	18	16.5	15	15	17
Unskilled Agri. labor	81.1	81.1	78.5	79.5	84.4	84.2	79.3	83.6	83.3	85	82	83.5	85	85	83
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Irrigated land	5.3	5.7	5.4	7.3	6.1	5.3	22.9	5.2	5.1	5	5.2	8.1			6.8
Non-irrigated land	94.7	94.3	94.6	92.7	93.9	94.7	77.1	94.8	94.9	95	94.8	91.9			93.2
Total	100	100	100	100	100	100	100	100	100	100	100	100			100

Overall skilled agricultural labor represents 17% of total agricultural labor while the remaining is unskilled as it does not utilize improved seeds, fertilizer, and irrigation nor extension services and is illiterate. Vegetables and fruit, wheat and maize production are relatively more intensive in skilled agricultural labor.

The share of irrigated land in agricultural production is very low averaging 6.8%. Vegetables and fruit production is relatively more intensive in irrigated land reaching 22.9% followed by coffee and maize. Cereal crop producing agricultural sub-sectors concentrate 35.7% of skilled labor and 26.5% of irrigated land. Cash crop sub-sectors concentrate 33.6% of skilled labor and 73.5% of irrigated land.

Value added is combined with intermediate consumption of goods and services to produce sector output. As reflected in the table below, agriculture is intensive in value added and uses little intermediate consumption. The manufacturing sector is relatively more intensive in semi finished and finished goods and services as intermediate inputs. In contrast, the services sector is intensive in intermediate inputs.

Table 3 - Shares in output

	Share in output			
	Agriculture	Manufacturing	Services	Total
Value added	87	62	47	62
Intermediate Consumption	13	38	53	38

Regarding the nature of these intermediate inputs, agriculture uses 47% of agricultural products, 37% come from manufacturing essentially composed of fertilizers and chemicals. It also uses services mainly financial services. The manufacturing sector uses 62% of manufacture products, 23% of agriculture products and 15% of services. 70% of agricultural inputs is demanded by agro processing industries. The services sector uses 50% of its intermediate inputs from the manufacturing sector and 44% from the services sector.

Agriculture produced 32.3% of total output. Its share in GDP is 40.9%. it represents 39.4% of exports and 41.7% of household consumption. The manufacturing sector is highly dependent on imports as 56% of total domestic supply is imported (manufacturing products represent 69.4% of imports) while only representing 17.1% of GDP and 14.4% of output.

Table 4 – Sectoral shares in GDP, output, exports, imports and household consumption

	Agriculture	Manufacturing	Services	Total
GDP	40.9	17.1	42	100
Output	32.3	14.1	53.6	100
Exports	39.4	21.2	39.4	100
Imports	4.6	69.4	26.1	100
Household consumption	41.7	34.7	23.7	100

The services sector is the most important in terms of share in GDP, share of total output and share of exports. Its share in total household consumption is relatively low amounting 23.7%.

Export intensity is low averaging 9.1%. 11.1 agricultural products are exported although they represent nearly 40% of total exports. Services are exported to 6.7% representing 39% of total exports and manufactured products to 13.7%. Import penetration amounts nearly 20% of total domestic supply with manufacturing products reaching 56% while agricultural products are mainly locally supplied with only 4% of imports.

63.4% of income from skilled agricultural labor is distributed to non poor rural households and the remaining to poor rural households. The share of the two households is similar regarding unskilled agricultural labor. non agricultural labor is distributed among urban households. 15.7% of irrigated land and 10% of non-irrigated land income is distributed to poor rural households. The remaining goes to non-poor rural households. Livestock income is distributed to the two rural households (respectively 32.6% and 67.4%). Non-poor rural households receive 60% of non-agricultural capital. The remaining is mainly distributed between public firms (10.8%), non-poor households in small urban settlements (13%) and poor rural households (7.3%).

Table 5 - Income composition of the different institutions

Accounts	Skilled Agri. labor	Unskilled Agri. labor	Admin &Prof labor	Unskilled n-a lab	Skilled n-a labor	Irrig. land	Non-irrig. land	Livestock	Non-agri capital	Transfers	Taxes	Total
Public firms									99.9	0.1		100
Government										19.1	80.9	100
Poor rural households	11.6	55.7	1			0.4	3.3	7.6	16.2	4.3		100
Non-poor rural households	6.6	32.8	1.7			0.7	9.9	5.2	41.1	2		100
Poor households in small urban settlements			6.8	20.3	51				8.2	13.7		100
Poor households in large urban settlements			15.8	8.4	46.5				10.9	18.3		100
Non-poor households in small urban settlements			9.6	7.5	31.3				43.9	7.7		100
Non-poor households in large urban settlements			10.4	4.2	35.7				29.6	20.1		100
Rest of the World									4.4	22.6		27

For households, the most important source of income is labor income. Land income is low representing 3.7% for poor rural households and 10.6% for the non-poor rural. Its share is much less than livestock income (7.6% and 5.2%). Non-agricultural capital represents 16.2% and 41.1% of poor and non-poor rural households. Public firms earn almost all their income from non-agricultural capital. 80.9% of government income comes from taxes while the remaining is from transfers. The rest of the world income is composed of return to capital (4.4%), transfers (22.6) and exports (73%).

In regards expenditure, households spend a bulk of their income on consumption of goods and services. Government account is in deficit implying that public investment is financed through loans and grants.

Table 6 – Expenditure of institutions

Accounts	Public firms	Govern ment	Poor rural households	Non-poor rural households	Poor households in small urban settlements	Poor households in large urban settlements	Non-poor households in small urban settlements	Non-poor households in large urban settlements	Rest of the World
Transfers	30.9	92.6						8	3.6
Taxes	19.1		0.3	0.2			12.1	11.2	
Consumpti on of G&S		59.4	96.2	97.6	97.6	95.4	86.3	77.1	30.1
Savings	50	-52	3.6	2.2	2.4	4.6	1.6	3.7	66.3
Total	100	100	100	100	100	100	100	100	100

Public firms invest half of their income and spend the rest on transfers and taxes. The current account balance is positive despite a trade deficit reaching 20% of GDP.

This section presented the major structure of the SAM. This structure will shape an important part of the simulation results.

The CGE Model

The study uses a dynamic computable general equilibrium (CGE) model. Major features of the model are presented in the following.

The CGE model used in this study follows the sectoral and socioeconomic structure of the SAM described in the previous section. This study uses an adapted version of the standard CGE model presented in Decaluwé, Martens and Savard (2001) and PEP standard CGE model presented in Decaluwé et al (2009).

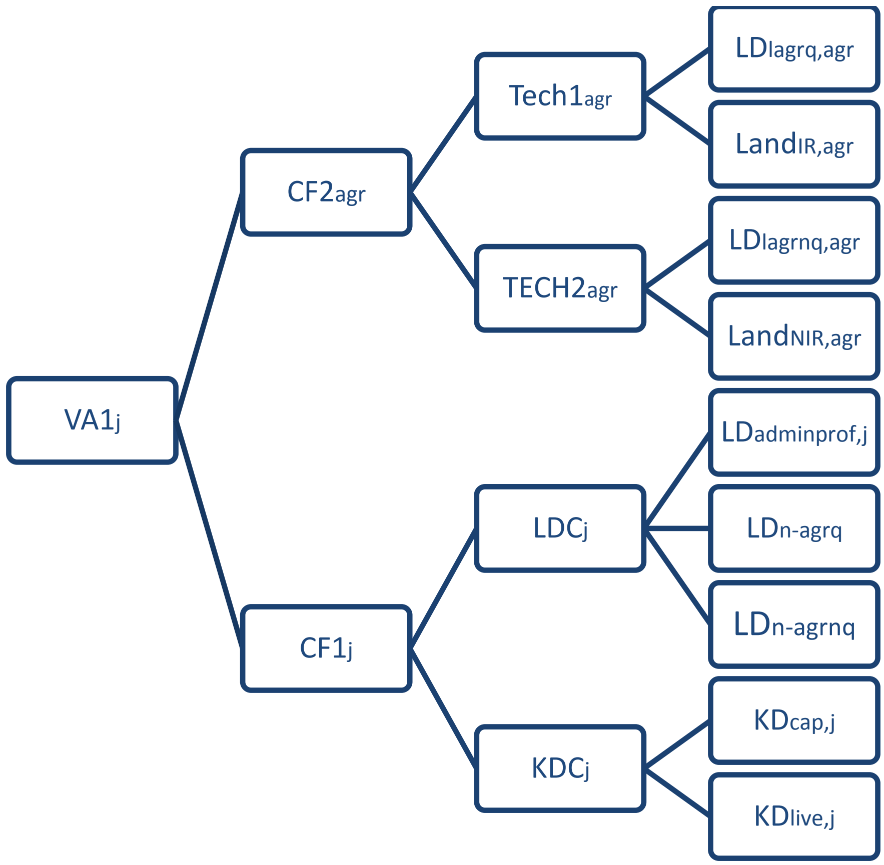
Our model runs on a dynamic basis enabling the evaluation of long-term impacts. We use a sequential dynamic model, to evaluate long-term impacts.The model will work in such a way that in each step or period, the stock of capital is accumulated and investment is allocated by sectors of destination following adapted specification for our case. The model runs for a period of 10 years starting from 2009/10 where the year 2015 is an important reference. 2015 marks the deadline for the attainment of the MDGs but also marks the end of the GTP, which will be implemented from EFY 2010/11 to 1014/15. The tenth year time line corresponds with the end of Ethiopia’s Agricultural Sector Policy and Investment Framework (PIF) 2010-2020.

The static standard model structure

Production - The production function in the model is a three level constant elasticity of substitution (CES) function. At the lowest level, skilled agricultural labor and irrigated land are aggregated into a more productive composite factor. In parallel, unskilled agricultural labor is combined with non-irrigated land into a less productive technology. Non-agricultural labor is also combined into a composite labor and the same for capital. To reflect the fact that the use of irrigation techniques requires skilled agricultural labor, the substitution elasticity is set at 0.3. This is also in line with the methodology used to disaggregate agricultural labor. Skilled labor is one that uses irrigation techniques, improved seeds, fertilizer, extension services and literate. Furthermore, setting a low substitution of elasticity is in line with the structure of agricultural production in Ethiopia which is labor-intensive.

Finally, government strategy is based on a labor-intensive approach that mobilizes rural labor as the main driver of growth and that targets labor-augmenting techniques. Non-irrigated land is combined with unskilled agricultural labor with a low elasticity of substitution as well of 0.8. At the intermediate level, we aggregate the high productivity composite factor with the lower productivity composite factor with a substitution elasticity of 1.5. In a similar approach, composite non-agricultural labor and composite capital are combined into a composite non-agricultural factor with a substitution elasticity of 1.5. The production function has an upper level which combines the latter with the composite agricultural factor with a substitution elasticity of 1.5. Finally, value added is combines in fixed proportions with intermediate inputs to make gross output.

Figure 9 -Structure of value added – three-level nested CES structure



VAj	Value added in industry j
CF1j	Composite factor in industry j
CF2j	Composite factor in agricultural sectors
Tech1agr	Technology 1 combining skilled agricultural labor and irrigated land in agricultural sectors
Tech2agr	Technology 2 combining unskilled agricultural labor and non-irrigated land in agricultural sectors
LDCj	Industry j demand for composite non-agricultural labor
KDCj	Industry j demand for non-agricultural capital and livestock capital
LDlagrq,agr	Demand for skilledagricultural labor by agricultural sectors
LDlagrnq,agr	Demand for unskilled agricultural labor by agricultural sectors
LandIR,agr	Demand for irrigated land by agricultural sectors
LandNIR,agr	Demand for non-irrigated land by agricultural sectors
LDadminprof,j	Demand for administrative and professional labor by industry j
LDn-agrq,j	Demand for non-agricultural skilled labor by industry j
LDn-agrnq,j	Demand for non-agricultural unskilled labor by industry j

Trade - The treatment of trade in the model is standard. We assume that the relationship between the rest of the world and the domestic economy is determined by an imperfect substitutability between imported and domestically produced goods and services on the consumption side (Armington hypothesis). Likewise, local producers divide their output between the home and export markets; the shares vary with the ratio of domestic prices to exports process. Thus, allocation between domestic and foreign markets for demand and supply respond to relative prices of foreign goods defined by exogenous international (import and export) prices, the real exchange rate and the local tax levels. Price elasticity of the world demand for exports of product is set at 2.

Factor market - To capture existing differences in labor markets, the model classifies employed labor into different sub-categories, including skilled and unskilled workers based on occupational categories. There are a total of 4 labor categories: Agricultural labor, Administrative workers and Professionals, Unskilled workers, and skilled workers. Agricultural labor is further disaggregated between skilled and unskilled farmers. This is important as the rationale behind an increase in investment in training for farmers (directly or through DAs) is that unskilled agricultural farmers will be enabled to acquire skill through training and thus transform from unskilled to skilled farmers (with higher productivity and thus higher wages). The model is calibrated in such a way that skilled agricultural wages are 30% higher that the unskilled enabling a level of skilled agricultural labor wages always higher than that of the unskilled even when the former fall. This is an acceptable range as skilled farmers are able to produce up to twice as much compared to unskilled ones (GTP). There are four labor markets corresponding to the four labor categories. Labor supply is fixed and wages adjust to changes in demand maintaining full employment. Agricultural labor is only employed in agriculture production and is mobile across agricultural sub-sectors.

Land is specific to agricultural production but can move freely across agricultural subsectors implying a shift in the type of crop produced (crop substitution). Each agricultural activity utilizes two types of land: irrigated and non-irrigated and there is a possibility to transform non-irrigated land into irrigated land through public investment in irrigation schemes. When the model is calibrated to reproduce the data in the SAM, return to irrigated land is 11.5% higher than that of non-irrigated land. This is also acceptable as the yield gap can reach 40% between rain fed and irrigated land in Ethiopia (Diao et al 2006). Non agricultural capital is sector specific.

Public investment in training and irrigation

Public investment, like private investment, is introduced in such a way that it increases the volume of capital. Total investment is the sum of both and an increase in public investment can have a crowding out effect.

Training will enable the production of skilled farm labor. Indeed, public investment in the form of the provision of free short term training for farmers combined with less skilled farm labor will enable the production of skilled/trained farm labor. In the case of irrigation investments, a combination of non-irrigated land with public investment capital for irrigation will allow the production of irrigated land.

In our model, public investment in training enables the increase in the supply of skilled agricultural labor by transforming the unskilled labor. As total agricultural labor supply is fixed, the supply of unskilled agricultural labor decreases while skilled agricultural labor increases. The same applies for land where public investment in irrigation enables the transformation of non-irrigated land into irrigated land.

Total agricultural labor supply (LST) is the sum of skilled $LS_{lagrq,t}$ and unskilled $LS_{lagrnq,t}$ agricultural labor supply. Skilled agricultural labor supply is fixed and grows with the population rate and public investment in training $IND_{cap,aeduc,t}$. Training is provided for free by government agents or in farmer training centers and does not have an opportunity cost.

$$LST_t = LS_{lagrq,t} + LS_{lagrnq,t}$$

$$LS_{lagrq,t} = LS_{lagrq,t-1}.pop_t.\left[\frac{IND_{cap,aeduc,t}}{IND_{cap,aeduc,t-1}.pop_t}\right]^{\sigma\_aeduc}$$

σ_aeduc is the elasticity of skilled labor supply to changes in public investment. It is set at 2.5. Unskilled agricultural labor supply is endogenously determined as the residue between total agricultural labor and skilled agricultural labor. The latter are both fixed and grow at the population growth rate.

Public investment in irrigation, $IND_{landir,j,t}$, increases the level of irrigated land, $KD_{landir,j,t}$, at agricultural sub-sector level. This is interesting as it enables to differentiate public investment in irrigation in food crops essentially destined for the domestic market and cash crops which are export intensive.

$$KD_{lanir,j,t} = KD_{landir,j,t-1}.1 - delta_{landir,j,} + IND_{landir,j,t-1}{}^{\sigma\_ir}$$

σ _ir is the elasticity of irrigated land supply to changes in public investment. It is set at 1.25. Sector level land capital is the sum of irrigated and non-irrigated land types. Land is mobile across agricultural sub-sectors. There is therefore possibility for crop substitution. Non-irrigated land, $KS_{landnir,t}$, is determined residually. It is the difference between total land supply

(SLAND) which is fixed and increases with population growth and irrigated land, $KS_{landir,t}$, which increases through public investment and population growth.

$$KST_{j,t} = KD_{landir,j,t} + KD_{landnir,j,t}$$

$$SLAND_t = KS_{landir,t} + KS_{landnir,t}$$

Endogenous household endowments

In a standard CGE model, households maintain fixed endowments in land, labor and capital. Our modeling approach will assume that households' endowments in labor (trained/skilled and untrained) and in land (irrigated and non-irrigated) is endogenous. As a consequence, the model will allow households to modify their factor endowments in land type and labor type. Households can modify, by getting training (by getting public capital for irrigation), the proportion of skilled/trained and unskilled labor (irrigated and non-irrigated land) they detain. It is to be noted that households do not have a demand function for getting training. We assume that receiving training does not have direct or opportunity costs at the household level.

Each household supplies ($LSTH_{h,t}$) a fixed share ($\theta 1_h$) of total agricultural labor supply (LST_t).

$$LSTH_{h,t} = \theta 1_h . LST_t$$

Here, the share of each household in total irrigated land and skilled labor supply remains unchanged. That is, if the total supply of skilled agricultural labor increases by 10%, each household will have the same level $\lambda_WL_{h,lagrq,t}$of increase. This implies that a 25% increase in skilled labor endowment does not have the same implications for the poor and the non-poor. However, if one assumes that public investment targets in priority the poor, one can modify the income distribution scheme enabling for instance poor rural households to transform a greater share of their unskilled labor compared to the non-poor rural households.

$$LSH_{h,lagrq,t} = \lambda\_WL_{h,lagrq,t} . LS_{lagrq,t}$$

Unskilled agricultural labor is determined residually for each household enabling a change in their labor endowments by skill, $\lambda\_HH_{h,l,t}$.

$$LSH_{h,lagrnq,t} = LSTH_{h,t} - LSH_{h,lagrq,t}$$

$$LSH_{h,lagrq,t} = \lambda\_HH_{h,lagrq,t} . LSTH_{h,t}$$

$$LSH_{h,lagrnq,t} = (1 - \lambda\_HH_{h,lagrq,t}).LSTH_{h,t}$$

The same procedure is used for land supply. Each household supplies (SLANDH) a fixed share (theta) of total agricultural land supply ($SLANDH_{h,t}$).

$$SLANDH_{h,t} = \theta_h.SLAND_t$$

Like agricultural labor, the share of each household in irrigated land income and supply, $\lambda\_RK_{h,lanir,t}$, remains unchanged but increases in the same rate for each household following public investment.

$$KSH_{h,landir,t} = \lambda\_RK_{h,lanir,t}.KS_{landir,t}$$

Non-irrigated land supply is set residually enabling a change in household endowments, $\lambda_HL_{h,l,t}$given that total household land supply is fixed and grows with population rate.

$$KSH_{h,landnir,t} = SLANDH_{h,t} - KSH_{h,landir,t}$$

$$KSH_{h,landir,t} = \lambda\_HL_{h,l,t}.SLANDH_{h,t}$$

$$KSH_{h,landnir,t} = (1 - \lambda\_HL_{h,l,t}).SLANDH_{h,t}$$

Household income - Households are defined by rural and urban areas and poor/non-poor categories. Income and expenditure patterns vary considerably across these household groups. These differences are important for distributional change, since incomes generated by agricultural growth accrue to different households depending on their location and factor endowments. Each representative household in the model is an aggregation of a group of households in the household survey. Households in the model receive income through the employment of their factors in both agricultural and non-agricultural production, and then pay taxes, save and make transfers to other households.

The major source of income for households is factor income. Rural households earn income from labor, capital, and land. Urban households earn income from capital and labor. Both types of households also get income from transfers from other institutions including the ROW. The disposable income of a representative household is allocated to commodity consumption derived from a Stone-Geary utility function. This detailed specification of production and factor markets in the model allows it to capture the changing scale and technology of production across sectors and sub-national regions, and therefore, how changes in the economic structure of growth influences its distribution of incomes.

Dynamic model specifications

We use a sequential dynamic model to evaluate long term impacts. In each period, the stock of capital (KD) is accumulated using the following equation.

$$KD_{k,j,t} = KD_{k,j,t-1}.\left(1 - \delta_{k,j}\right) + IND_{k,j,t-1}$$

$\delta_{k,j}$ Depreciation rate of capital k in industry j

$IND_{k,j,t}$ Investment demand by sector of destination

The allocation of new private capital between categories and industries follows a modified version of the Jung-Thorbecke (2001) investment demand specification. The volume of new type *k* capital allocated to business-sector industry *bus* is proportional to the existing stock of capital; and the proportion varies according to the ratio of the rental rate to the user cost of that capital. Investment demand is defined following the specification of Bourguignon et al (1989). It is given by the equation below.

$$\frac{IND_{k,bus,t}}{KD_{k,bus,t}} = \varphi_{k,bus}.\left[\frac{R_{k,bus,t}}{U_{k,bus,t}}\right]^{\sigma\_INV_{k,bus}}$$

Capital accumulation rate (the ratio of investment demand, IND, to capital demand, KD) increases with the ratio of the rate of return, $R_{k,bus,t}$ and its user cost, $U_{k,bus,t}$. The user cost of capital is as follows:

$$U_{k,bus,t} = PK_{PRI_t}(\delta_{k,bus} + ir_t)$$

PK_{PRI_t} Price of new private capital

ir_t Interest rate

$R_{k,bus,t}$ Rental rate of type k capital in industry j

$\varphi_{k,bus}$ Scale parameter (allocation of investment to industries)

$\sigma\_INV_{k,bus}$ Elasticity (investment demand)

An increase in public investment may result in crowding out private investment as specified below.

$$IT\_PRI_t = IT_t - IT\_PUB_t - \sum_i PC_{i,t}VSTK_{i,t}$$

IT_t Total investment expenditures

IT_PRI_t Total private investment expenditures

IT_PUB_t Total public investment expenditures

$PC_{i,t}$ Purchaser price of composite commodity i

$VSTK_{i,t}$ Inventory change of commodity i

Public investment by category and by public sector industry grows at the population growth rate pop(time). The user cost of public capital is similar to that of private capital:

$$IND_{k,pub,t} = IND_{k,pub,t-1}.pop_t$$

$$U_{k,pub,t} = PK\_PUB_t.(\delta_{k,bus} + ir_t)$$

PK_PUB_t Price of new public capital

The population growth rate is used in the model to update the values of variables, both endogenous and fixed variables, and parameters that are assumed to grow at that rate.

Model closure

The model is run for 10 periods of time. Non-agricultural capital is sector-specific and exogenously set at the base year level for the first period of time. Land is mobile across agricultural sub-sectors. Non-agricultural labor is fully mobile across all sectors. Agricultural labor is mobile in agricultural sub-sectors. Both agricultural and non-agricultural wages adjust to ensure full employment.

All commodity markets follow the neoclassical market-clearing system in which each market is cleared when the total endogenous demand equals the total supply through price adjustment. Our numeraire is the nominal exchange rate. World import and export prices are set fixed following the small price-taking economy hypothesis. Current account balance is set fixed at the first period and increases yearly with population growth.

Other variables that grow at the population growth rate are: minimum consumption of commodities in the LES demand equations, government current expenditures, public investment by category and by public sector industry, and changes in inventories. Likewise, total investment expenditure is equal to the sum of agents' savings. For the savings-investment account, real investment adjusts to changes in savings (i.e., savings-driven investment). Also, the sum of the different forms of investment expenditure is equal to total investment.

Calibration of parameters

Based on the SAM, the production technologies across all sectors are calibrated to their current situation, including each sector's use of primary inputs, such as land, labor and capital, and intermediate inputs. Exogenous elasticities including substitution and transformation elasticities have been taken from other studies focusing on the same country and while some are values used in the PEP type model.

Poverty analysis within the CGE framework

When considering impacts of public investment, it is important to evaluate poverty effects. Increased or more efficiently allocated public resources within the agricultural sector are expected to generate increased growth. However, the nature of the growth process is determinant for poverty reduction. Poverty reduction requires an increase in real wages or real income. Here, the extent to which agricultural growth involves growth in marginal product of labor is important. A poverty analysis is therefore essential to capture the full impact of an alternative reallocation of public resources for the agricultural sector as the resulting economic growth may not be pro-poor.

The study investigates this by using a "top-down" approach where changes in the CGE model are imported in the household data. It uses micro data from the 2004/05 HIES. The survey does not provide data on household income but rather on household expenditure. Household income will therefore be approximated by consumption expenditure. The top-down approach captures effects of changes in consumption prices on household expenditure and poverty. At the top level, the CGE model is used to measure changes in commodity prices and household consumption. These changes are then fed into the HIES to evaluate changes in household expenditure. Each representative household in the CGE model is linked to its corresponding households within the micro simulation model.

Poverty changes are then evaluated using the standard measures. The Foster Greer and Thorbecke (FGT) measures are applied.

$$\boldsymbol{P_{\alpha} = \frac{1}{Nz^{\alpha}} \sum_{j=1}^{J} (z - y_j)^{\alpha}}$$

Where j is a subgroup of individuals with consumption below the poverty line (z), N is the total sample size, y is expenditure of a particular individual j and α is a parameter for distinguishing between the alternative FGT indices[1]. This poverty extension enables us to calculate poverty incidence, poverty depth and the severity.

The data used is from the 2004/5 Household Income Consumption and Expenditure Survey (HICES) of Ethiopia. The survey is nationally representative and has detailed information on household consumption expenditure, consumption patterns, income and household characteristics such as agro ecology zone (AEZ), number of persons (household size) and socio-economic characteristics. Non-parametric approaches are used based on the observed distribution of these households in the survey, their sample weights, number of individuals in the household and their location (i.e rural/urban). Each household questioned in HICES 2004/05 is linked directly to the corresponding representative household in the model.

The SAM used in the CGE component of the model is the 2005/06 EDRI SAM updated for 2009/10. So that the survey data used in the micro simulation component has to be of the same year. Unfortunately, the 2009/10 HICES hasn't been yet released. For that reason the recent available 2004/05 HICES was updated. The 2004/5 weight of the survey households was scaled up to achieve the country's 2009/10 total population but we assume household size remains the same. The per capita consumption expenditure is inflated by a factor which gives us the 2009/10 poverty incidence. As a result, the base year poverty incidence is a reasonable rate based on the government report (MoFED 2012).

Measuring Food insecurity within the CGE framework

Availability of food and access are common indicators of food security. Availability of food can be measured by nationwide food supply indicators while access can be captured through household consumption of food staples. Access to food can also be captured through the country's capacity to finance its current food imports through trade. We focus on the availability approach.

To measure the impact on food insecurity, we use as proxy the volume of total agricultural output, the total labor force, and commodities' price. If total agricultural output divided by total labor force increases (FSindex1), this means that there are more goods produced per individual. This is a first indication on the potential for such a policy intervention on reducing food insecurity. However, as our labor force is fixed within one period of time, the food

[1] When $\alpha=0$ the expression simplifies to J/N, or the headcount ratio. This is a measure of the incidence of poverty. When $\alpha=1$ the expression gives us poverty depth measured by the poverty gap. When $\alpha=2$ the expression gives us the severity of poverty measured by the squared poverty gap.

insecurity indicator will only reflect changes in volume of output. To verify whether this type of policy intervention has a real potential to contribute to reducing food insecurity, it is important to look at the changes across time in the food security index to check whether it allows a more accelerated reduction (relative to the first period) in food insecurity compared to the Business As Usual (BAU) (FSindex2a).

$$FSindex1_{agr_t} = \frac{\sum_{agr} XST_{agr,t}}{\sum_{l} LS_{l,t}}$$

$$FSindex2_{agr_{t>1}} = \left[\frac{\left(\frac{\sum_{agr} XST_{agr,t}}{\sum_{l} LS_{l,t}}\right)}{\left(\frac{\sum_{agr} XST_{agr,t1}}{\sum_{l} LS_{l,t1}}\right)} - 1\right]$$

The results may show that the policy has a potential to reducing food insecurity. However, this applies if consumer prices remain unchanged or decrease. We upgrade our simplified food insecurity index by integrating the consumer price index (FSindex3).

$$FSindex3_{agr_{t>1}} = \left[\frac{\left(\frac{\sum_{agr} XST_{agr,t}}{\sum_{l} LS_{l,t}}\right)}{\left(\frac{\sum_{agr} XST_{agr,t1}}{\sum_{l} LS_{l,t1}}\right)} - 1\right] \cdot \left[\frac{1}{1 + \left(\frac{CPI_t}{CPI_{t1}} - 1\right)}\right]$$

Another point that may be raised when using such an index based on the total agricultural output is the relevance of this indicator as total agricultural output is composed of food as well as non-food items. In addition, when it comes to reducing food insecurity, it is important to focus on the major food staples. In the Ethiopian case, the latter are composed of cereal namely teff, barley, wheat, maize, sorghum and other cereal crops such as oats. We therefore recalculate our food security index by using the total output in these food crops (the indexes are FSindex1a, FSindex2a, and FSindex3a).

Finally, agricultural output may be destined to exports reducing the food available on the local market. Similarly, food may be imported increasing food availability. We therefore push our analysis further by using total domestic supply of agricultural products (local output minus exports plus imports). Our index distinguishes between total domestic supply of agricultural goods and that of food crops as discussed above (the indexes are FSindex1b, FSindex2b, and FSindex3b when using total domestic supply of agricultural goods and FSindex1c, FSindex2c, and FSindex3c when using total domestic supply of major food staples).

Scenarios

In this section, increased total factor productivity resulting from public investment in farmer training and irrigation are simulated. While assuming that a 10% increase in public investment for training would result in a 2% increment of TFP is not based on empirical facts (the same for a 15% increase in irrigation budget), it is in our view an acceptable assumption. Constrained by available information on the quantitative relationship between agricultural TFP and such investment in Ethiopia, we calculated the scope of our simulations based on the GTP. The GTP has set a number of ambitious targets for 2014/15 and to meet these objectives an important public expenditure plan has been designed. Among different indicators for the agricultural sector, the following are of interest to the present study and were utilized in calculating the scope of the simulations.

- Crop productivity is targeted to grow by 29.4% between 2009/10 and 2014/15 with an annual average of 5.8%
- The number of extension services beneficiaries is targeted to grow by 187% in 2014/15 with an annual average of 37.5%
- Land developed under community based water shade development program is targeted to grow by 106% between 2009/10 and 2014/15 with an annual average of 21%
- Land developed under small scale irrigation is planned to grow by 116.8% between 2009/10 and 2014/15 with an annual average of 23.3%

To meet these targets, expenditure in agriculture and food security is projected to grow at an average of 30% annually till 2014/15 the major investment areas being irrigation and extension services. Therefore, assuming a 10% increase in training budget and a 15% increase in investment for irrigation would result in a 2% rise in agricultural TFP (labor and land combined) is in inline with the projected figures in government agenda.

Table 7 – Summary of scenarios

	Scenario	Time frame
Simulation 1	10% increase in public investment for farmers' training 2% improvement in skilled labor and irrigated land productivity	2nd period and shock takes effect on the 3rd period to increase skilled labor supply 3rd period and level maintained until last period
Simulation 2	15% increase in public investment in irrigation uniformly across all agricultural sub-sectors (complemented by food crops versus cash crops investment choice) 2% improvement in skilled labor and irrigated land productivity	2nd period and shock takes effect on the 3rd period to increase irrigated land supply 3rd period and level maintained until last period
Simulation 3	Combination of the above two simulations	2nd period and shock takes effect on the 3rd period to increase skilled labor and irrigated land supply

Looking at studies that focused on public investment in agriculture and irrigation on other African countries, we find that our elasticity of TFP is of an acceptable scope. Benin et al (2009) find that a 1% increase in public spending on agriculture is associated with a 0.15% increase in agricultural labor productivity in Ghana. Diao et al (2010) find that a 1% increase in agricultural spending is associated with a 0.24% annual increase in agricultural TFP in Nigeria. Thurlow et al (207) use an elasticity of TFP of 0.20 for investment in irrigation and 0.15 for spending on extension.Other studies utilize agricultural growth (instead of agricultural TFP growth) as the dependent variable when measuring the impact of public investment in agriculture.

Our Elasticity of TFP is higher than those obtained from other studies of African countries in which agricultural growthelasticity to public investment amounts0.15 in a cross-sectional study of African countries as a whole (Benin et al. 2007), 0.17 for Rwanda (Diao et al. 2007), and 0.19 for Uganda (Fan et al. 2004).However, these studies estimate public spending in agriculture in general while our study focuses on spending on extension services through which farmers are trained and investment in irrigation.

These types of spending have higher potential for increasing TFP. Fan et al (2006) find that additional government spending on agricultural research and extension has the largest impact on agricultural productivity growth in rural India. Fan et al (2004) also find that government expenditure on agricultural extension and research has the highest returns in labor productivity in Uganda. Regarding irrigation, the literature is mixed in regards the benefits of irrigation.Some studies find lower return to irrigation (Fan et al 1999, Fan et al 2006, Thurlow et al 2007) while others find positive effects (Bhattarai et al. 2002, Huang et al. 2006). Huang et al (2006) find that irrigation raises yields for most crops (yields of wheat by 17.7%, those of maize by 29.4%, and those of cotton by 28.4%). The impact of irrigation becomes even greater on household crop revenue where irrigation increases revenue by 76.1%. In both rich and poor areas, irrigation has a significantly positive effect on crop revenue, increasing it by 132.8% in rich areas and 43.9% in poorer ones.

Finally, we also looked at studies that focus on agriculture in Ethiopia although not directly related to public spending to cross-check the scope of chocks applied to TFP. Dorosh and Thurlow (2009) use crop yield observed in 2005/06 and apply yield growth rates based on expected improvements in the performance of different crop sectors over a ten year period assuming the rate of growth of investments continues as before. In their baseline scenario, they assume that average annual agricultural growth will stand at 3.8% per year with an annual average of crop yield growth of 1.13%. In their accelerated agricultural growth scenario where the agricultural sector would grow at 6% every year, annual average of crop yield groth was set at 2.04%.

To further analyze the sensitivity of required spending with respect to the choice of elasticity, we consider a case in which the elasticity is 25% higher and another where it is 25% lower for both types of public investments.

Our model is built in such a way that public expenditure in training increases the share of skilled agricultural labor while investment in irrigation increases the share of irrigated land. We use targets set in the GTP when determining growth in skilled labor and irrigated land following public budget increment. With a 30% annual increase in agricultural investment, the GTP targets to attain a 37.5% annual increase in the number of extension services beneficiaries. Based on this, a 10% increase in training budget would enable a 12.5% increment in skilled agricultural labor. In addition, given that Ethiopian small holder farming mainly uses family labor farming skills and techniques being transferred across generation, we believe that if one member of a household acquires such skills, it would be transferred to at least another member of the same household. In short, we assume that training one person would have a positive externality. Accordingly, a 10% increment in training budget enables a 23.9% growth in skilled agricultural labor. Although this results into having 1.9 million more skilled farmers, it only reduced the level of the unskilled by 3.4%. With regard to irrigation, we apply the projections in the GTP. A 15% increase in irrigation spending enables a 23.1% growth of irrigated land by transforming 1.7% of total non irrigated land.

Impact of public investment in training and irrigation

The first scenario simulates a 10% increase in public investment on farmers'training applied inthe second period which will be effective inthe third period. This is complemented by a 2% total factor productivity shock in the third period (Table7). For the same level of skilled agricultural labor and irrigated land, total agricultural output increases by 2%. As it is presented earlier, the model closure assumes full employment in the agricultural sector. This implies that an increase in the supply of skilled agricultural labor due to public investment will result in the reduction of skilled labor wages. However, this is not realistic in that skilled labor has higher productivity and thus higher wages. This is partially offset by the productivity shock which introduces rigidity in wages.

The second scenario simulates a 15% increment of public investment in irrigation uniformly across all agricultural sub-sectors during the second period taking effect in the third period. This is complemented by a productivity shock of skilled labor and irrigated land of the same type as in the first simulation. Furthermore, we also try to see whether the gains in terms of growth, food security and poverty differ if irrigation expenditure is to target food crops versus cash crops. The third scenario combines the above two public investments.

We focus on two reference years: 2014/15 which is the timeline for attaining the MDS and the targets set in the GTP while 2019/20 represents the end of the PIF. The Business As Usual (BAU) scenario is the basis for comparison. Changes in 2014/15 and 2019/20 are reported relative to the levels in the BAU for the two reference years. Policy simulation results are structured to address the three main objectives of this paper:

- Potential for growth and an agriculture-led development
- Potential for reducing food insecurity
- Potential for poverty reduction

SIM1, SIM2 and SIM3 correspond to the three scenarios outlined in Table 7.

Impact on agricultural growth and overall GDP: is there an agriculture-led development?

Table 8 presents the changes in return to agricultural land and labor following the public investment shocks. Given the increased pool of skilled labor, return to skilled labor declines although less when investmentin training and irrigation are combined. Owing to the low substitution elasticity between skilled agricultural labor and irrigated land, the increase in skilled labor translates into higher demand for irrigated land, for which supply is fixed. The same applies when public spending targets irrigation. Return to irrigated land increases by more than 40% in 2015 and 2020. In parallel, unskilled agricultural wages increase a little having become relatively rare. The latter is combined with non-irrigated land in a CES with low substitution elasticity translating into a contraction in return to non-irrigated land becomes now relatively more abundant.

Table 8 – Changes in return to factors

	Time	Return to factors			
		Skilled agricultural labor	Unskilled agricultural labor	Irrigated land	Non-irrigated land
SIM1	2014/15	-16.2%	0.3%	44.1%	-3.9%
	2019/20	-16.2%	0.4%	42.9%	-4.3%
SIM2	2014/15	4.9%	-1.4%	-33.9%	0.0%
	2019/20	4.8%	-1.5%	-33.9%	0.0%
SIM3	2014/15	-12.9%	0.2%	-6.8%	-2.0%
	2019/20	-13.1%	0.2%	-5.4%	-2.1%

With a 15% increase in public investment in irrigation, return to irrigated land drops significantly although the decline is much less when investment in irrigation is combined with spending on training (Table 8, SIM2 and 3). Skilled agricultural wages increase by nearly 5% both in 2015 and 2020. No changes occur in return to non-irrigated land while unskilled agricultural wages reduce by 1.4% in 2015 and by 1.5% in 2020. A combination of the two types of investments appears to be better as agricultural labor wages decline relatively less in particular considering the high labor intensity of household income.

The increased pool of skilled labor and/or irrigated land combined with greater productivity enables a higher level of composite factor at a lower cost. As reflected in Table 9, total agricultural value added particularly in crops sectors increases in all three scenarios although more when public spending combines irrigation and training. Value added in manufacturing sector declines (because of crowding out effect) while it increases a little in services sector. Overall value added increases by 1% or less in volume across all scenarios.

Table 9 – Changes in value added

	Time	Value Added (volume)				
		Agriculture	Manufacturing	Services	Agriculture Crops	Total economy
SIM1	2014/15	1.9%	-0.1%	0.2%	2.5%	0.9%
	2019/20	1.9%	0.1%	0.3%	2.5%	1.0%
SIM2	2014/15	1.5%	-0.1%	0.1%	2.1%	0.7%
	2019/20	1.5%	0.0%	0.1%	2.1%	0.7%
SIM3	2014/15	2.1%	-0.1%	0.2%	2.8%	1.0%
	2019/20	2.1%	-0.1%	0.2%	2.8%	1.0%

GDP at basic prices slightly declines in the first and third scenarios (Table 10) as the price of value added falls. It remains unchanged when public funds are geared towards irrigation development (SIM2). Overall GDP at market price contracts a little in the first and third scenarios while in slightly grows in the second. Agricultural growth contracts in all scenarios. GDP slightly increases in manufacturing sectors while all types of public investments yield growth in services sectors.

In addition, the increase in public investment in training has a crowding-out effect (Table 11). Although private investment does not contract (except a little in 2020 when investment in training is combined with irrigation) it grows significantly less than public investment, it grows at a decreasing rate and finally, its growth rate is also less than that of total investment. This affects the growth potential of the economy, in particular the manufacturing (and services) sectors that are highly capital-intensive.

Table 10 – Changes in GDP at basic price and final demand

	Time	GDP_BP	GDP_FD	GDP_FD agriculture	GDP_FD manufacturing	GDP_FD services
SIM1	2014/15	-0.2%	-0.1%	-0.5%	-0.1%	0.2%
	2019/20	-0.3%	-0.2%	-0.6%	-0.3%	0.1%
SIM2	2014/15	0.0%	0.1%	-0.2%	0.2%	0.2%
	2019/20	0.0%	0.0%	-0.2%	0.1%	0.1%
SIM3	2014/15	-0.1%	-0.1%	-0.4%	0.1%	0.2%
	2019/20	-0.2%	-0.1%	-0.5%	-0.1%	0.1%

Table 11 – Changes in total, private and public investment

	Time	Total investment	Private investment	Public investment
SIM1	2014/15	0.6%	0.4%	1.5%
	2019/20	0.5%	0.2%	1.3%
SIM2	2014/15	0.4%	0.2%	0.9%
	2019/20	0.3%	0.1%	0.8%
SIM3	2014/15	0.6%	0.1%	2.2%
	2019/20	0.5%	-0.1%	2.1%

To assess the potential of such policies to generate an agriculture-led development, we look at production and consumption linkages. Agriculture is linked to other sector through forward and backward linkages. Backward linkages imply an increase in demand for industrial products used as inputs for agricultural production. Public investment in training and or irrigation results in an increase in agricultural output (Table 12). Although agriculture is not intensive in the intermediate inputs, it uses 47% of agricultural products, 37% of manufacturing inputs essentially composed of fertilizers and chemicals and 17% of services mainly financial services as intermediate inputs in production and transport services. The expansion in agricultural output may translate into an increase in demand for manufacturing good and services.

Table 12 – Changes in total and sectoral output

	Time	Output (volume)				
		Agriculture	Manufacturing	Services	Agriculture Crops	Total economy
SIM1	2014/15	1.9%	-0.1%	0.3%	2.8%	0.8%
	2019/20	1.9%	0.1%	0.4%	2.7%	0.8%
SIM2	2014/15	1.3%	-0.1%	0.1%	1.8%	0.5%
	2019/20	1.3%	-0.1%	0.1%	1.8%	0.5%
SIM3	2014/15	2.0%	-0.1%	0.2%	2.8%	0.8%
	2019/20	1.9%	-0.1%	0.3%	2.8%	0.8%

Agriculture-led development through backward linkages does not take place here to generate growth in manufacturing sector where output contracts. Growth linkages apply to the services sectors to a certain extent as output in increases a little.

The three types of policy simulations have a positive outcome as the intermediate demand price index falls (Table 13). This may be a source of agriculture-led development.

Table 13 – Changes in intermediate demand price index

	Time	Intermediate demand price index	Intermediate demand Price index for agricultural commodities
SIM1	2014/15	-0.5%	-3.9%
	2019/20	-0.7%	-4.0%
SIM2	2014/15	-0.2%	-2.4%
	2019/20	-0.3%	-2.5%
SIM3	2014/15	-0.4%	-3.9%
	2019/20	-0.5%	-3.9%

Due to the fall in the prices of agricultural products, those industries that are intensive in agricultural intermediate inputs will benefit, in particular agro-processing industries. Forward linkages whereby the agricultural sector would provide inputs and raw material to the industrial and other sectors also operate here. 23% of intermediate inputs utilized in the manufacturing sector and 17% of those utilized in the services sector are agricultural products for which prices have fallen (Table 13). Forward linkages whereby the agricultural sector would provide inputs and raw materials to the manufacturing and other sectors operate here but the decline in agricultural prices does not translate into an expansion in the manufacturing sector.

Agriculture-led development can also occur via consumption linkages. Increases in agricultural income could lead to increased demand for non-agricultural final consumption goods. This however depends on the composition of household consumption basket and household income elasticities of consumption. Changes in agricultural factor income are reflected in Table 14.

Table 14 – Changes in agricultural factors income

		agricultural labor income	land income	livestock income
SIM1	2014/15	-2.0%	-0.2%	-0.7%
	2019/20	-2.0%	-0.1%	-0.9%
SIM2	2014/15	-0.4%	-3.6%	-0.3%
	2019/20	-0.4%	-3.5%	0.4%
SIM3	2014/15	-1.3%	-2.8%	-0.7%
	2019/20	-1.4%	-2.7%	-0.2%

Consumption linkages do not operate here. Total agricultural labor income declines driven by the drop in skilled agricultural wages when training budget increases and when the latter is combined with increases in public investment in irrigation (Table 14). In the second scenario, the small decline in unskilled agricultural wages overrides the increase in return to skilled labor. Similarly, land income declines in all scenarios despite the over 40% risein return to irrigated land in the first scenario (because the share of irrigated land in total land is only 6.8%). The productivity shock introduced is not high enough to counter the drop in return to land and labor. Finally, income from livestock capital also contracts. Livestock capital is utilized only in this sector. It is private capital that has been slightly affected by the crowding out effect of public investment.

Changes in agricultural output and prices affects the country's competitiveness. Agriculture plays an important role in Ethiopia as it provides the bulk of exports and export revenue vital for importing essential raw material and inputs. It is to be noted here that the structure of the SAM underestimates the actual share of agriculture in total exports. We tried to correct this when updating the SAM but were constrained by the capacity of the optimization process. Table 15 presents the simulation results.

Table 15 – Changes in exports and imports

		Agriculture	Manufacturing	Services	Total
SIM1		Exports (volume)			
	2014/15	3.8%	-0.1%	-0.4%	1.4%
	2019/20	3.8%	0.1%	-0.2%	1.6%
		Imports (volume)			
	2014/15	-3.9%	0.5%	0.8%	0.4%
	2019/20	-3.9%	0.4%	0.8%	0.4%
SIM2		Exports (volume)			
	2014/15	3.6%	-0.3%	-0.4%	1.3%
	2019/20	3.6%	-0.2%	-0.4%	1.4%
		Imports (volume)			
	2014/15	-2.1%	0.3%	0.6%	0.3%
	2019/20	-2.1%	0.3%	0.6%	0.3%
SIM3		Exports (volume)			
	2014/15	4.6%	-0.4%	-0.5%	1.6%
	2019/20	4.6%	-0.2%	-0.5%	1.7%
		Imports (volume)			
	2014/15	-3.7%	0.5%	0.9%	0.4%
	2019/20	-3.7%	0.4%	0.8%	0.4%

Total exports in all scenarios increase although slightly more when investment in training is combined with irrigation spending.Overall exports are pulled by growing agricultural exports which represent 39.4% of total exports. Agricultural output has increased and commodities prices have declined making the products more competitive. Export increase the most in export-intensive sectors mainly producing cash crops. Exports increase the most for pulses followed by flowers, oil seeds and vegetable and fruit. Exports of food crops also increase as local prices have fallen more than international prices making it more profitable for producers to export than to supply the local market. Export of non agricultural products decline a little as output has contracted or didn't increase enoughwhile prices have increased. Considering a fixed current account balance, the expansion in exports enables the country to increase its imports.

Total imports increase by as little as 0.4% in the first and last scenarios and by 0.3% in the second one. At the sectoral level, imports of agricultural products decline in all scenarios. Import demand falls for these products as the locally produced are less expensive. Imports of manufacturing goods which represent 70% of total imports increase by 0.5% or less. Imports of fertilizer increase the most as it is utilized in the agricultural sector and pulled by the expansion of output. Imported services increase by 0.9% the last period pulled by demand for trade services utilized by the agricultural sector for exporting purposes. The effect of the policy scenarios on agriculture led development was low partly because even if agricultural production uses 37% of intermediate manufacturing inputs, a significant share of the latter are imported. This weakens the production linkages between agriculture and manufacturing sectors.

Impact on food insecurity

Food security is measured using the availability approach. It is affected by two factors: agricultural output and commodities prices. As presented in the above section, agricultural output has increased. In parallel to that, agricultural commodities' price has fallen (Table 16). Only changes in food security index 3 and its sub-components will be presented and discussed. The results regarding indexes 1 and 2 are available in the Annex.

Table 16 – Changes in consumer price index

	Consumer price index					
	Time	**Total**	Agricultural commodities	Manufacturing commodities	Services	Agricultural food crops
SIM1	2014/15	-0.9%	-2.7%	0.0%	0.2%	-3.6%
	2019/20	-1.0%	-2.8%	0.0%	0.0%	-3.5%
SIM2	2014/15	-0.8%	-2.7%	0.1%	0.3%	-3.5%
	2019/20	-0.9%	-2.8%	0.1%	0.2%	-3.5%
SIM3	2014/15	-0.5%	-1.6%	0.2%	0.3%	-2.1%
	2019/20	-0.4%	-1.8%	0.2%	0.2%	-2.2%

Figure 9 presents the changes in the food security index3 which takes into account changes in consumer price index. All type 3 indexes show the policy has potential for reducing food insecurity and this in a more accelerated manner compared to BAU scenario. Food supply increases faster than in the BAU scenario and prices decrease with a more important pace compared to the BAU scenario. The result tables are available in the Annex.

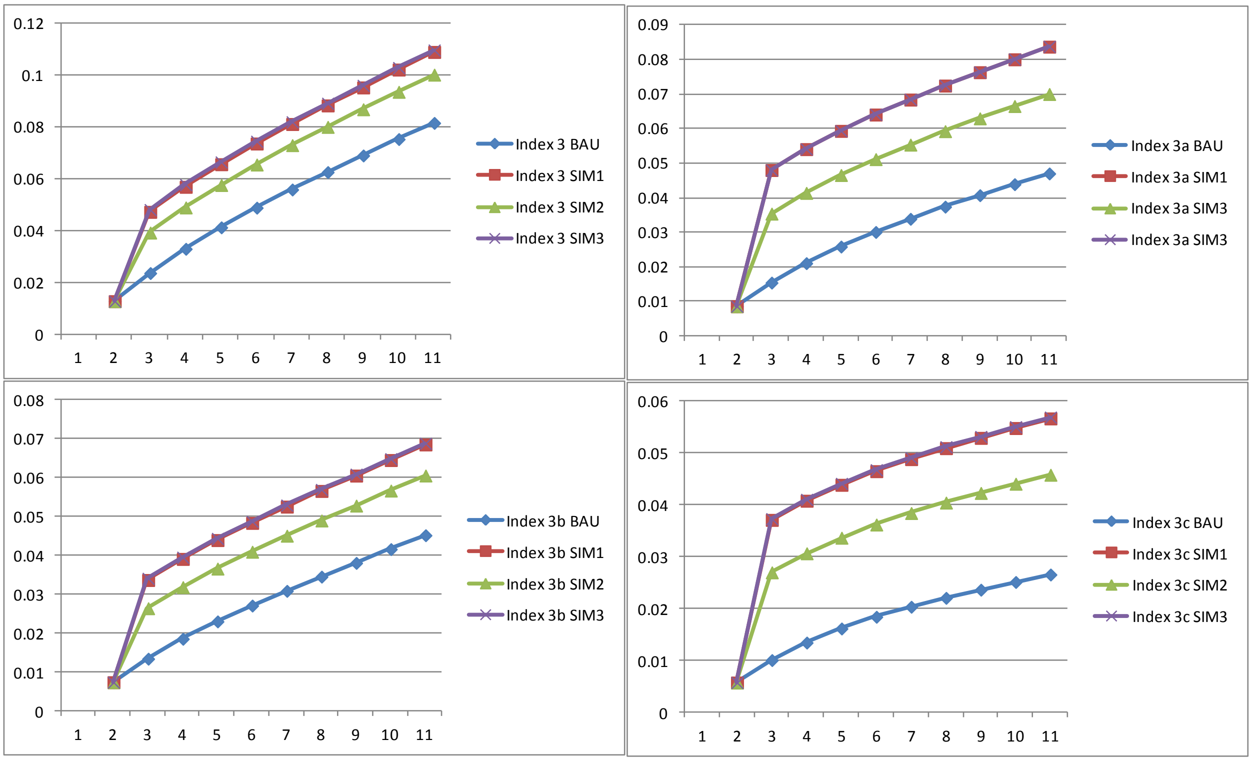
Whether we use total agricultural output or output of major food staples, all investment schemes have a potential for reducing food insecurity. Investing in farmer training has significantly more potential than investing in irrigation only. Combining both investment in training and irrigation does not reduce more food insecurity as changes in output from the combined approach and the one focusing on training only are similar. The difference comes from the changes in agricultural CPI where prices fall more when government invests in training than when the two types of investments are combined.

When it comes to reducing food insecurity, it is important to focus on the major food staples. In the Ethiopian case, the latter are composed of cereal namely teff, barley, wheat, maize, sorghum and other cereal crops such as oats. When we look at our food security index by using the total output in these food crops (the indexes are FSindex1a, FSindex2a, and FSindex3a), we find that the policy interventions have even greater potential for reducing food insecurity. Indeed, output of these major food crops/cereals increases by one percentage point more that total agricultural output. In addition, their price declines even further. Public investment in training for farmers and irrigation has therefore a great potential for reducing food insecurity.

We simulated two additional scenarios to see whether it is more interesting to invest public resources for irrigation towards food crops as opposed to cash crops. The results show that focusing on food crops reduces food insecurity although at a much lesser pace than if irrigation is developed for all crops. In this case, as cash crops are more intensive in irrigated land, a certain shift away from food crops takes place. When irrigation targets cash crops, the impact on food insecurity is minimal in particular when considering total output and domestic supply of major food staples. The tables reflecting the results are provided in the Annex.

Finally, agricultural output may be destined to exports reducing the food available on the local market. Similarly, food may be imported increasing food availability. When considering total domestic supply of agricultural products instead of total agricultural output, the three policies are still positive in enabling the reduction of food insecurity despite the higher increase in agricultural exports compared to output expansion (see FSindex3b in Figure 9). Our index finally distinguishes between total domestic supply of agricultural goods and that of food crops. The positive effect of the three policies is again reflected when using this index (see FSindex3c in Figure 9).

Figure 9 – Changes in food security index 3a and 3b, SIM1, SIM2, SIM3



Impact on poverty

Public investment in training and or irrigation will reduce poverty if it increases household real consumption. It will be pro-poor if it improves the situation of the poorest. As presented in Table 8, agricultural labor, land and livestock incomes decline. In contrast, non-agricultural capital income increases as well as non-agricultural labor income (see last Table 2d in Annex).

Table 16 – Changes in income by household type

	SIM1		SIM2		SIM3	
	2014/15	2019/20	2014/15	2019/20	2014/15	2019/20
Poor rural households	-1.1%	-1.1%	-0.3%	-0.3%	-0.8%	-0.9%
Non-poor rural households	-0.4%	-0.5%	-0.2%	-0.2%	-0.4%	-0.4%
Poor households in small urban settlements	0.5%	0.3%	0.4%	0.3%	0.6%	0.4%
Poor households in large urban settlements	0.4%	0.2%	0.4%	0.3%	0.5%	0.3%
Non-poor households in small urban settlements	0.6%	0.3%	0.5%	0.4%	0.7%	0.5%
Non-poor households in large urban settlements	0.4%	0.2%	0.4%	0.3%	0.5%	0.3%

Changes in agricultural and non agricultural factor income affect households depending on their endowments. Poor rural households earn 67.3% of their income from skilled and unskilled agricultural labor, 3.7% from land, 7.6% from livestock capital and 16.2% from non-agricultural capital. For the non-poor, the income composition is less dependent on agricultural labor income and relatively more intensive in non-agricultural capital income. Non-poor rural households earn 39.4% of their income from skilled and unskilled agricultural labor, 10.6% from land, 5.2% from livestock capital and 41.1% from non-agricultural capital. Rural poor and rural non-poor households see their nominal income decline in all public investment scenarios although the effect is larger for the rural poor (Table 16). As poor rural households are less endowed in non-agricultural capital, for which income has increased, they are relatively more affected by the drop in agricultural factor income. Urban households earn their income from non-agricultural capital and labor. Return to non-agricultural factors having increased, this positively affects their overall nominal income which increases although by less that 1%.

In parallel to these income effects, there are price effects that also affect the consumption level and pattern of representative households. The CPI has dropped in all three scenarios and agricultural commodities prices have fallen even more Table 16). These commodities hold an important share in the consumer food basket in Ethiopia making the drop in agricultural CPI (and in particular prices of food crops) more important for increasing household consumption.

Table 17 presents the results of the three public investment scenarios.

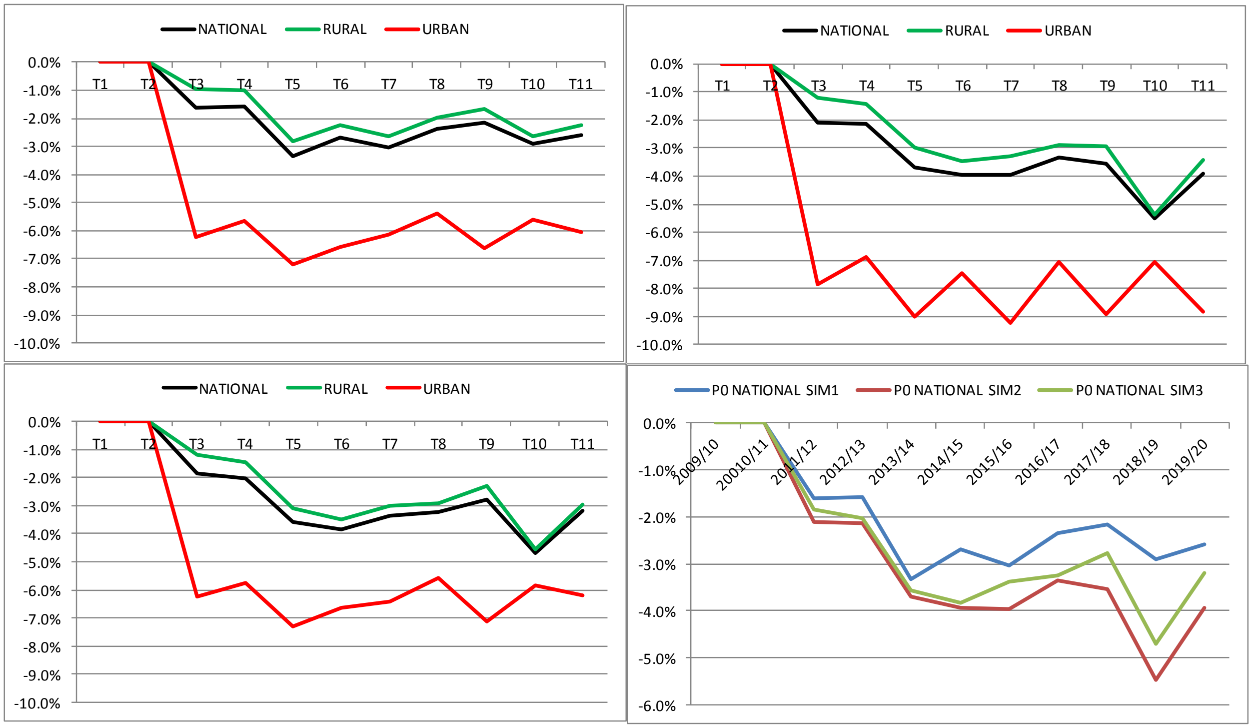
Table 17 – Changes in FGT indices

		2009/10 (BAU)			2014/15			2019/20		
		P0	P1	P2	P0	P1	P2	P0	P1	P2
SIM1	NATIONAL	29.9	6.3	1.9	21.8	4.0	1.2	13.1	2.2	0.6
	RURAL	30.6	6.5	2.0	23.4	4.3	1.2	14.3	2.4	0.7
	URBAN	26.5	5.6	1.8	13.9	2.5	0.7	7.4	1.2	0.3
	NATIONAL				-2.7%	-2.7%	-3.4%	-2.6%	-3.5%	-3.2%
	RURAL				-2.2%	-2.0%	-2.4%	-2.3%	-2.4%	-3.0%
	URBAN				-6.6%	-6.7%	-6.6%	-6.1%	-7.6%	-8.6%
SIM2	NATIONAL	29.9	6.3	1.9	21.5	4.0	1.1	13.0	2.2	0.6
	RURAL	30.6	6.5	2.0	23.1	4.3	1.2	14.1	2.4	0.6
	URBAN	26.5	5.6	1.8	13.8	2.4	0.7	7.2	1.2	0.3
	NATIONAL				-3.9%	-3.9%	-4.2%	-3.9%	-4.8%	-4.8%
	RURAL				-3.5%	-3.2%	-3.1%	-3.4%	-4.0%	-4.5%
	URBAN				-7.5%	-9.0%	-9.2%	-8.8%	-9.9%	-11.4%
SIM3	NATIONAL	29.9	6.3	1.9	21.5	4.0	1.1	13.1	2.2	0.6
	RURAL	30.6	6.5	2.0	23.1	4.3	1.2	14.2	2.4	0.7
	URBAN	26.5	5.6	1.8	13.9	2.5	0.7	7.4	1.2	0.3
	NATIONAL				-3.8%	-3.6%	-4.2%	-3.2%	-4.4%	-4.8%
	RURAL				-3.5%	-3.2%	-3.1%	-2.9%	-3.6%	-3.0%
	URBAN				-6.6%	-7.1%	-7.9%	-6.2%	-7.6%	-8.6%

The micro-simulation results show that poverty declines by 2.7%, 3.9% and 3.8% in 2015 resulting from increased public spending in training, in irrigation and their combination respectively. Gains in terms of poverty reduction are higher when investment targets irrigation. However, the impact is only slightly better than when skill development and irrigation are combined. Furthermore, when looking at rural poverty where most of the poor are concentrated, the two policies have the same impact.

As reflected by the Figure 10, urban poverty declines more than rural poverty in all scenarios. This is due to the fact that urban households' income increased while that of rural households declined. This means that the policy has positive outcomes in terms of reducing poverty but it is not pro-poor. Indeed, if we look at the poverty incidence at the base year, it is higher than the national average (29.9%) for rural households (30.6%) while it is much lower for urban ones (26.5%). P0 declines significantly more for urban households.

Figure 10 – Changes in poverty incidence: national rural and urban



Poverty depth and poverty severity also decline when considering national level variations in all three investment schemes. However, at a more disaggregated level, the policy intervention is not pro-poor. The poverty gap is much higher for the rural population but it declines less than that of urban households. According to the poverty severity index, compared to urban households, rural households have a higher risk of being in poverty, but their poverty is not significantly more severe (2.0 For rural and 1.8 for urban). Nevertheless, the policy is not pro-poor as P2 declines much more for urban households. However, it is to be noted that although it is not pro-poor, poverty incidence, poverty gap and poverty severity decline for all types of households. In addition, rural settings concentrate over 80% of the population. Therefore, a 3.5% decline in poverty incidence in rural areas resulting from public investment for skill development and irrigation will pull out of poverty a much greater number of poor than a 6.6% reduction in urban settings. This is substantiated by the scope of the changes in national poverty incidence being just above those of rural poverty.

Sensitivity analysis

To check the sensitivity of our results, we run a sensitivity analysis. We consider a case in which the elasticity of TFP is 25% higher and another where it is 25% lower for both types of public investments. We run the simulations for the first and second scenarios. We briefly discuss the results for the first scenario followed by the second for the year 2015. The result tables are available in the Annex.

Sensitivity analysis of public investment in training

Impact on agricultural growth and overall GDP: is there an agriculture-led development?

In regards growth and agriculture led development, the sensitivity analysis shows that having a TFP 25% higher or 25% lower does not change the trend. Both GDP at basic prices and GDP at market prices decline. As in SIM1, agricultural growth as well as GDP in manufacturing sectors contract while that of services sector expands (Table 3a). Production linkages do not allow expansion of output in manufacturing sector. Agricultural output increase by 2.6% with the higher TFP scenario while it increases by 1.6% with a lower TFP compared to a 1.9% growth in the initial simulation (Table 5a).

Impact on food insecurity

The consumer price index stood at -0.9% in the initial simulation. In the higher TFP scenario, prices decline by 0.8% and by 1.3% with the lower TFP scenario (Table 9a). In terms offood insecurity, the higher TFP scenario has a much higher potential (Figure 1a) as output increases significantly more although prices decline relatively less compared to the initial scenario. This shows that if government is to reduce food insecurity, public investment should be designed to increase productivity.

Impact on poverty

The trend in changes in household income remains unchanged. Rural households see their nominal income decline while urban households experience and increase (Table 10a). In terms of poverty reduction, 25% higher productivity enables a 7.1% increase in national poverty incidence reduction from -2.7% to -3% while 25% lower TFP affects significantly the gains in poverty reduction by contracting the reduction rate by 28.5% from -2.7% to -2.1% (Table 11a). When TFP is higher, rural poverty declines more quickly (-2.2% to -2.8%) while urban poverty declines at a lower rate (-6.6% to -4.8%). This can be an indication that if public investment in skill development increases sufficiently agricultural TFP, it can accelerate poverty reduction and it can also be pro-poor.

Sensitivity analysis of public investment in irrigation

Impact on agricultural growth and overall GDP: is there an agriculture-led development?

In regards growth and agriculture led development, the sensitivity analysis shows that having a TFP 25% higher or 25% lower does not change the trend. GDP at basic prices stagnates and GDP at market prices increases by the same level for the lower productivity scenario (Table 3b). As in SIM2, agricultural growth contracts while that of manufacturing and services sectors expand a little (Table 3b). Production linkages do not allow expansion of output in manufacturing sector. Agricultural output increase by 2% with the higher TFP scenario while it increases by 1.0% with a lower TFP compared to a 1.9% growth in the initial simulation (Table 5b).

Impact on food insecurity

The consumer price index stood at -0.3% in the initial simulation. In the higher TFP scenario, prices decline by 0.7% and by 0.5% with the lower TFP scenario (Table 9b). In terms of food insecurity, the higher TFP scenario has a higher potential (Figure 1b) as output increases slightly more but prices decline significantly more compared to the initial scenario.

Impact on poverty

The trend in changes in household income remains unchanged. Rural households see their nominal income decline while urban households experience and increase (Table 10b). In terms of poverty reduction, 25% higher productivity enables a 15.3% increase in national poverty incidence reduction from -3.9%% to -4.5% while 25% lower TFP affects significantly the gains in poverty reduction by contracting the reduction rate by half (compared to the initial decline rate) from -3.9% to -2.6% (Table 11b). When TFP is higher, rural poverty declines more quickly (-3.5% to -402%) while urban poverty declines at a lower rate (-7.5% to -6.6%). This can be an indication that if public investment in irrigation increases sufficiently agricultural TFP, it can accelerate poverty reduction and it can also be pro-poor.

Conclusion

This research paper attempted to measure the potential impact of public investment in farmer training and irrigation schemes. Skill development and irrigation are two targeted areas of government agriculture development policy. We use a dynamic CGE model to simulate a 10% increase in public investment for farmers' training and a 15% increment in investment for irrigation. Three scenarios are simulated, one for each type of investment and a third one that combines the two. All public investment increment simulations are complemented by a productivity shock that increases the productivity of skilled agricultural labor and irrigated land with regards to agricultural output of 2%. The model is run over a period of 11 years. A poverty module is constructed using a top-down approach based on household income and expenditure survey. The analysis of simulation results is structured to address three major questions: i) What is the impact on growth and is there an agriculture-led development? 2)What are the potentials of the policy to reduce food insecurity? Iii) Can such investments reduce poverty and is the policy pro-poor?

Overall, the three simulations have show that investing in irrigation alone has a great potential for growth, food security and poverty reduction. However, given that the economy is labor intensive, investing in training for farmers in combination with investment in irrigation has a greater potential forreducing food insecurity and poverty in particular if one considers long term and sustainable productivity and production gains. While our results do not show a notable difference in the gains from irrigation only and a combination of irrigation and skill development, this is also due to the fact that we apply the same productivity increment across the three scenarios due to lack of data on elasticity of TFP to public investment in training and irrigation. With a higher TFP elasticity, the impact is greater when both investments are combined. Furthermore, investing in irrigation only will not yield the expected results without agricultural labor that has the required skill. In addition, these trainings and irrigation schemes should enable a greater increase in productivity as the 2% increase simulated here is not sufficient to bring about notable changes in particular with raising theincome of the rural poor. If public investment in irrigation and skill development can further increase productivity, the policy will also be pro-poor. Overall, such investment would accelerate the efforts deployed by the Ethiopian government to meet the MDGs.

The results also show that an agriculture led development is less likely to occur because even if over one third of intermediate inputs utilized in agricultural production come from the manufacturing sector, a significant share of these inputs are imported. This weakens the production linkages between agriculture and manufacturing sectors. Exports expand and in particular in cash crops that have the potential of generating higher income at household level and national level by increasing foreign currency inflows necessary for importing inputs including fertilizers for agricultural production.

The increment in public investment has crowding-out effects that affects the expansion of manufacturing and services sectors which are highly intensive in non-agricultural private capital. This exercise showed that the Ethiopian government policy strategy regarding agriculture sector development has a great potential for reducing poverty and food insecurity. An agriculture-led development does not occur in our case also because of the contraction of private investment in the manufacturing sector. Financing such investment plans may require an alternative allocation of public resources or even a different financing mechanism.

Our analytical framework does not account for private costs which can be particularly highwhen setting up irrigation schemes. As Ethiopian rural farmers are generally poor, availability of credit will be essential to the success of such investment. Training these farmers will be indispensable if investment in irrigation is to be productive. Put this way, it seems inevitable to combine investment in irrigation with skill development. From the cost perspective, and given the current structure of Ethiopia's agricultural system, investing in skills development may have notable impact in a relatively shorter period of time.

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Annex - Sensitivity analysis

Investment in education: +25% and -25% improvement in TFP

Table 1a – Changes in return to factors

		Return to factors			
		Skilled agricultural labor	Unskilled agricultural labor	Irrigated land	Non-irrigated land
SIM1	2014/15	-16.2%	0.3%	44.1%	-3.9%
	2019/20	-16.2%	0.4%	42.9%	-4.3%
SENS1	2014/15	-15.7%	-0.4%	47.5%	-3.9%
	2019/20	-15.7%	-0.4%	44.6%	-4.3%
SENS2	2014/15	-16.4%	0.7%	42.4%	-3.9%
	2019/20	-16.5%	0.7%	41.1%	-2.1%

Table 2a – Changes in value added

		Value Added (volume)				
		Agriculture	Manufacturing	Services	Agriculture Crops	Total economy
SIM1	2014/15	1.9%	-0.1%	0.2%	2.5%	0.9%
	2019/20	1.9%	0.1%	0.3%	2.5%	1.0%
SENS1	2014/15	2.7%	-0.1%	0.3%	3.5%	1.2%
	2019/20	2.6%	0.1%	0.4%	3.4%	1.3%
SENS2	2014/15	1.6%	0.0%	0.2%	2.0%	0.7%
	2019/20	1.5%	0.1%	0.3%	2.0%	0.8%

Table 3a – Changes in GDP at basic price and final demand

	Time	GDP_BP	GDP_FD	GDP_FD agriculture	GDP_FD manufacturing	GDP_FD services
SIM1	2014/15	-0.2%	-0.1%	-0.5%	-0.1%	0.2%
	2019/20	-0.3%	-0.2%	-0.6%	-0.3%	0.1%
SENS1	2014/15	-0.2%	-0.2%	-0.7%	-0.1%	0.3%
	2019/20	-0.3%	-0.3%	-0.7%	-0.3%	0.1%
SENS2	2014/15	-0.1%	-0.1%	-0.4%	0.1%	0.2%
	2019/20	-0.2%	-0.1%	-0.5%	-0.1%	0.1%

Table 4a – Changes in total, private and public investment

	Time	Total investment	Private investment	public investment
SIM1	2014/15	0.6%	0.4%	1.5%
	2019/20	0.5%	0.2%	1.3%
SENS1	2014/15	0.8%	0.6%	1.6%
	2019/20	0.6%	0.4%	1.4%
SENS2	2014/15	0.6%	0.1%	2.2%
	2019/20	0.5%	-0.1%	2.1%

Table 5a – Changes in total and sectoral output

	Time	Output (volume)				
		Agriculture	Manufacturing	Services	Agriculture Crops	Total economy
SIM1	2014/15	1.9%	-0.1%	0.3%	2.8%	0.8%
	2019/20	1.9%	0.1%	0.4%	2.7%	0.8%
SENS1	2014/15	2.6%	-0.1%	0.3%	3.7%	1.1%
	2019/20	2.5%	0.1%	0.5%	3.7%	1.1%
SENS2	2014/15	1.6%	-0.1%	0.2%	2.3%	0.6%
	2019/20	1.5%	0.1%	0.3%	2.3%	0.7%

Table 6a – Changes in intermediate demand price index

	Time	Intermediate demand price index	Intermediate demand Price index for agricultural commodities
SIM1	2014/15	-0.5%	-3.9%
	2019/20	-0.7%	-4.0%
SIM2SENS1	2014/15	-0.7%	-5.2%
	2019/20	-1.0%	-5.3%
SENS2	2014/15	-0.4%	-3.3%
	2019/20	-0.6%	-3.3%

Table 7a – Changes in agricultural factors income

		agricultural labor income	land income	livestock income
SIM1	2014/15	-2.0%	-0.2%	-0.7%
	2019/20	-2.0%	-0.1%	-0.9%
SENS1	2014/15	-2.3%	-0.8%	-0.8%
	2019/20	-2.4%	-0.8%	-1.1%
SENS2	2014/15	-1.8%	0.2%	-0.6%
	2019/20	-1.6%	0.2%	-0.9%

Table 8a – Changes in exports and imports

		Agriculture	Manufacturing	Services	Total
		Exports (volume)			
	2014/15	3.8%	-0.1%	-0.4%	1.4%
	2019/20	3.8%	0.1%	-0.2%	1.6%
		Imports (volume)			
	2014/15	-3.9%	0.5%	0.8%	0.4%
SIM1	2019/20	-3.9%	0.4%	0.8%	0.4%
		Exports (volume)			
	2014/15	5.3%	-0.2%	-0.5%	2.0%
	2019/20	5.4%	0.2%	-0.3%	2.2%
		Imports (volume)			
	2014/15	-5.0%	0.6%	1.1%	0.5%
SENS1	2019/20	-5.0%	0.6%	1.1%	0.5%
		Exports (volume)			
	2014/15	4.6%	-0.4%	-0.5%	1.6%
	2019/20	4.6%	-0.2%	-0.5%	1.7%
		Imports (volume)			
	2014/15	-3.7%	0.5%	0.9%	0.4%
SENS2	2019/20	-3.7%	0.4%	0.8%	0.4%

Table 9a – Changes in consumer price index

		Consumer price index				
	Time	Total	Agricultural commodities	Manufacturing commodities	Services	Agricultural food crops
SIM1	2014/15	-0.9%	-2.7%	0.0%	0.2%	-3.6%
	2019/20	-1.0%	-2.8%	0.0%	0.0%	-3.5%
SENS1	2014/15	-0.8%	-2.2%	-0.1%	0.1%	-3.0%
	2019/20	-0.8%	-2.3%	0.0%	0.0%	-3.0%
SENS2	2014/15	-1.3%	-3.5%	0.0%	0.3%	-4.7%
	2019/20	-1.2%	-3.5%	0.0%	0.0%	-4.6%

Figure 1a – Changes in food security index 3a and 3b, SIM1, SENS1, SENS2

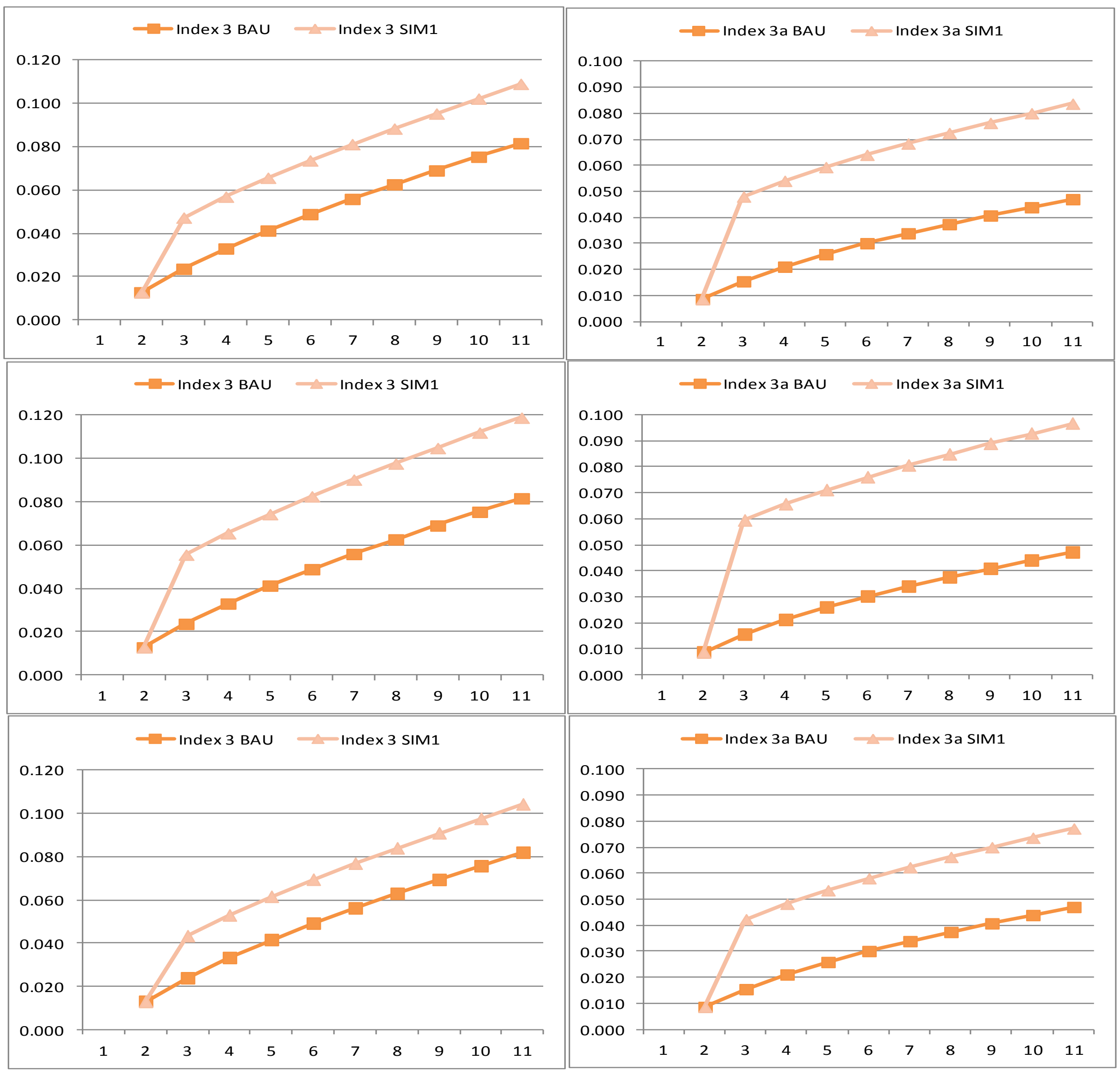

Table 10a – Changes in income by household type

	SIM1		SENS1		SENS2	
Household income	2014/15	2019/20	2014/15	2019/20	2014/15	2019/20
Poor rural households	-1.1%	-1.1%	-1.3%	-1.3%	-0.8%	-0.9%
Non-poor rural households	-0.4%	-0.5%	-0.5%	-0.6%	-0.4%	-0.4%
Poor households in small urban settlements	0.5%	0.3%	0.6%	0.4%	0.6%	0.4%
Poor households in large urban settlements	0.4%	0.2%	0.5%	0.3%	0.5%	0.3%
Non-poor households in small urban settlements	0.6%	0.3%	0.8%	0.5%	0.7%	0.5%
Non-poor households in large urban settlements	0.4%	0.2%	0.5%	0.3%	0.5%	0.3%

Table 11a – Changes in FGT indices

		2009/10 (BAU)			2014/15			2019/20		
		P0	P1	P2	P0	P1	P2	P0	P1	P2
	NATIONAL	29.9	6.3	1.9	21.8	4.0	1.2	13.1	2.2	0.6
	RURAL	30.6	6.5	2.0	23.4	4.3	1.2	14.3	2.4	0.7
	URBAN	26.5	5.6	1.8	13.9	2.5	0.7	7.4	1.2	0.3
	NATIONAL				-2.7%	-2.7%	-3.4%	-2.6%	-3.5%	-3.2%
	RURAL				-2.2%	-2.0%	-2.4%	-2.3%	-2.4%	-3.0%
SIM1	URBAN				-6.6%	-6.7%	-6.6%	-6.1%	-7.6%	-8.6%
	NATIONAL	29.9	6.3	1.9	21.7	4.0	1.2	13.1	2.2	0.6
	RURAL	30.6	6.5	2.0	23.2	4.3	1.2	14.2	2.4	0.7
	URBAN	26.5	5.6	1.8	14.2	2.5	0.7	7.6	1.2	0.3
	NATIONAL				-3.0%	-3.2%	-3.4%	-2.9%	-3.9%	-4.8%
	RURAL				-2.8%	-2.9%	-3.1%	-2.8%	-3.2%	-3.0%
SENS1	URBAN				-4.8%	-4.9%	-5.3%	-4.2%	-5.3%	-5.7%
	NATIONAL	29.9	6.3	1.9	21.9	4.0	1.2	13.3	2.2	0.6
	RURAL	30.6	6.5	2.0	23.5	4.3	1.3	14.5	2.4	0.7
	URBAN	26.5	5.6	1.8	14.0	2.5	0.7	7.5	1.2	0.3
	NATIONAL				-2.1%	-2.2%	-2.5%	-1.4%	-2.6%	-3.2%
	RURAL				-1.6%	-1.6%	-1.6%	-1.0%	-2.0%	-1.5%
SENS2	URBAN				-5.7%	-5.6%	-5.3%	-5.3%	-6.1%	-5.7%

Investment in irrigation: +25% and -25% improvement in TFP

Table 1b – Changes in return to factors

		Return to factors			
		Skilled agricultural labor	Unskilled agricultural labor	Irrigated land	Non-irrigated land
SENS1	2014/15	5.7%	-2.1%	-32.2%	-2.0%
	2019/20	5.6%	-2.1%	-32.1%	0.0%
SIM2	2014/15	4.9%	-1.4%	-33.9%	0.0%
	2019/20	4.8%	-1.5%	-33.9%	0.0%
SENS2	2014/15	4.5%	-1.1%	-33.9%	0.0%
	2019/20	4.4%	-1.1%	-33.9%	0.0%

Table 2b – Changes in value added

		Value Added (volume)				
		Agriculture	Manufacturing	Services	Agriculture Crops	Total economy
SENS1	2014/15	2.2%	-0.1%	0.1%	3.0%	1.0%
	2019/20	2.2%	0.0%	0.2%	3.0%	1.0%
SIM2	2014/15	1.5%	-0.1%	0.1%	2.1%	0.7%
	2019/20	1.5%	0.0%	0.1%	2.1%	0.7%
SENS2	2014/15	1.2%	-0.1%	0.0%	1.6%	0.5%
	2019/20	1.1%	-0.1%	0.0%	1.6%	0.5%

Table 3b – Changes in GDP at basic price and final demand

	Time	GDP_BP	GDP_FD	GDP_FD agriculture	GDP_FD manufacturing	GDP_FD services
SENS1	2014/15	0.0%	0.0%	-0.3%	0.3%	0.2%
	2019/20	-0.1%	0.0%	-0.3%	0.1%	0.1%
SIM2	2014/15	0.0%	0.1%	-0.2%	0.2%	0.2%
	2019/20	0.0%	0.0%	-0.2%	0.1%	0.1%
SENS2	2014/15	0.0%	0.1%	-0.1%	0.2%	0.1%
	2019/20	0.0%	0.0%	-0.1%	0.1%	0.1%

Table 4b – Changes in total, private and public investment

	Time	Total investment	Private investment	public investment
SENS1	2014/15	0.6%	0.5%	1.0%
	2019/20	0.5%	0.3%	0.9%
SIM2	2014/15	0.4%	0.2%	0.9%
	2019/20	0.3%	0.1%	0.8%
SENS2	2014/15	0.3%	0.1%	0.9%
	2019/20	0.2%	0.0%	0.8%

Table 5b – Changes in total and sectoral output

	Time	Output (volume)				
		Agriculture	Manufacturing	Services	Agriculture Crops	Total economy
SENS1	2014/15	2.0%	-0.1%	0.2%	2.6%	0.8%
	2019/20	1.9%	0.0%	0.2%	2.6%	0.8%
SIM2	2014/15	1.3%	-0.1%	0.1%	1.8%	0.5%
	2019/20	1.3%	-0.1%	0.1%	1.8%	0.5%
SENS2	2014/15	1.0%	-0.1%	0.1%	1.3%	0.4%
	2019/20	1.0%	-0.1%	0.1%	1.3%	0.4%

Table 6b – Changes in intermediate demand price index

	Time	Intermediate demand price index	Intermediate demand Price index for agricultural commodities
SENS1	2014/15	-0.4%	-3.6%
	2019/20	-0.5%	-3.7%
SIM2	2014/15	-0.2%	-2.4%
	2019/20	-0.3%	-2.5%
SENS2	2014/15	-0.1%	-1.8%
	2019/20	-0.2%	-1.9%

Table 7b – Changes in agricultural factors income

		agricultural labor income	land income	livestock income
SENS1	2014/15	-0.7%	-4.3%	-0.5%
	2019/20	-0.8%	-4.2%	0.2%
SIM2	2014/15	-0.4%	-3.6%	-0.3%
	2019/20	-0.4%	-3.5%	0.4%
SENS2	2014/15	-0.2%	-3.2%	-0.3%
	2019/20	-0.2%	-3.1%	0.5%

Table 8b – Changes in exports and imports

		Agriculture	Manufacturing	Services	Total
		Exports (volume)			
	2014/15	5.1%	-0.4%	-0.5%	-0.5%
	2019/20	5.1%	-0.2%	-0.4%	-0.4%
		Imports (volume)			
	2014/15	-3.2%	0.5%	0.9%	0.4%
SENS1	2019/20	-3.2%	0.4%	0.9%	0.4%
		Exports (volume)			
	2014/15	3.6%	-0.3%	-0.4%	1.3%
	2019/20	3.6%	-0.2%	-0.4%	1.4%
		Imports (volume)			
	2014/15	-2.1%	0.3%	0.6%	0.3%
SIM2	2019/20	-2.1%	0.3%	0.6%	0.3%
		Exports (volume)			
	2014/15	2.8%	-0.3%	-0.3%	1.0%
	2019/20	2.8%	-0.2%	-0.3%	1.0%
		Imports (volume)			
	2014/15	-1.5%	0.2%	0.5%	0.2%
SENS2	2019/20	-1.6%	0.2%	0.5%	0.2%

Table 9b – Changes in consumer price index

		Consumer price index				
	Time	Total	Agricultural commodities	Manufacturing commodities	Services	Agricultural food crops
SENS1	2014/15	-0.7%	-2.4%	0.2%	0.4%	-3.2%
	2019/20	-0.8%	-2.7%	0.2%	0.2%	-3.2%
SIM2	2014/15	-0.3%	-1.3%	0.1%	0.2%	-1.6%
	2019/20	-0.3%	-1.4%	0.2%	0.2%	-1.6%
SENS2	2014/15	-0.5%	-1.6%	0.2%	0.3%	-2.1%
	2019/20	-0.4%	-1.8%	0.2%	0.2%	-2.2%

Figure 1b – Changes in food security index 3a and 3b, SIM2, SENS1, SENS2

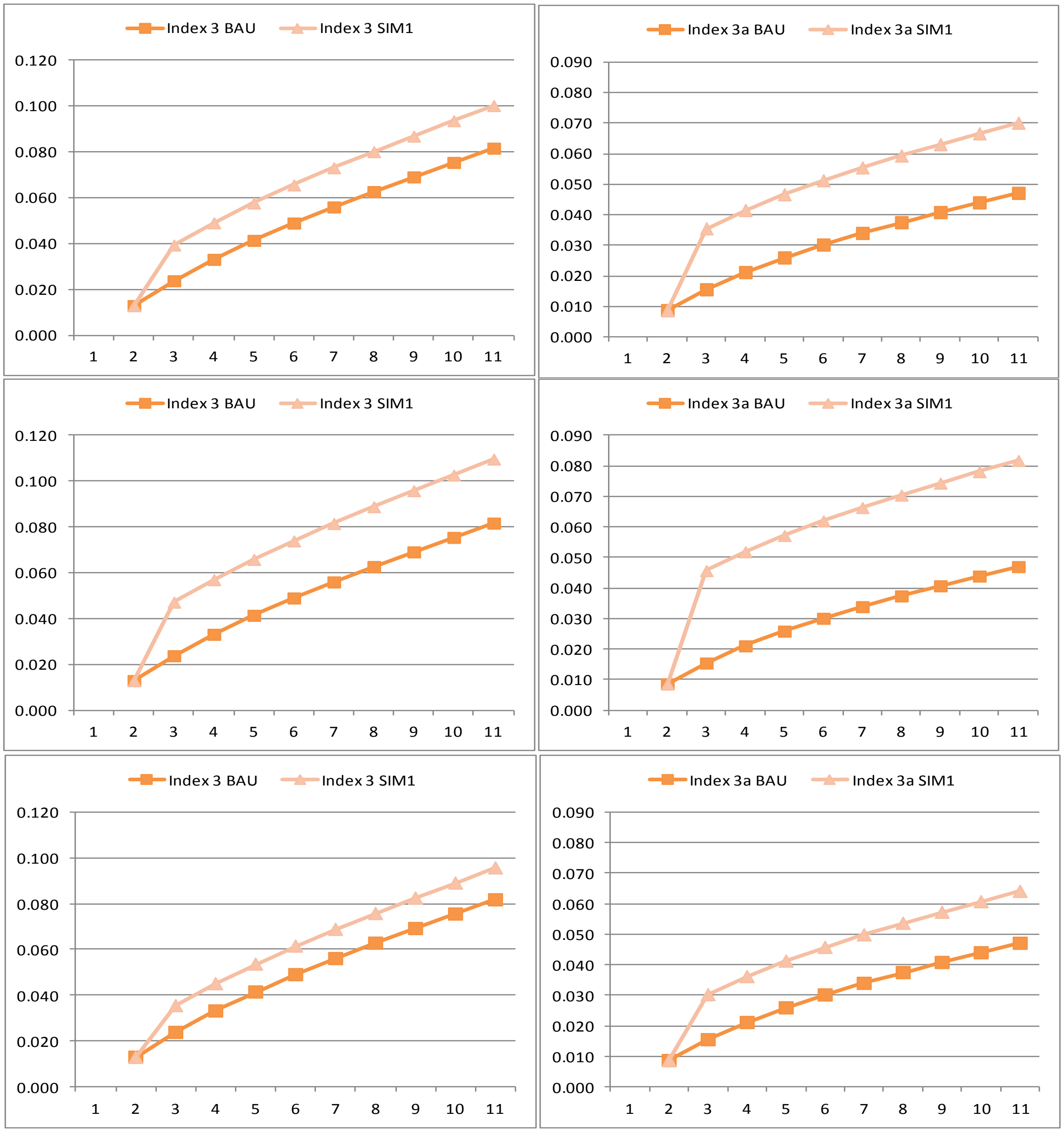

Table 10b – Changes in income by household type

	SENS1		SIM2		SENS2	
Household income	2014/15	2019/20	2014/15	2019/20	2014/15	2019/20
Poor rural households	-0.5%	-0.6%	-0.3%	-0.3%	-0.2%	-0.2%
Non-poor rural households	-0.3%	-0.4%	-0.2%	-0.2%	-0.1%	-0.2%
Poor households in small urban settlements	0.6%	0.4%	0.4%	0.3%	0.3%	0.3%
Poor households in large urban settlements	0.5%	0.4%	0.4%	0.3%	0.3%	0.2%
Non-poor households in small urban settlements	0.7%	0.5%	0.5%	0.4%	0.4%	0.3%
Non-poor households in large urban settlements	0.5%	0.4%	0.4%	0.3%	0.3%	0.2%

Table 11b – Changes in FGT indices

		2009/10 (BAU**)**			2014/15			2019/20		
		P0	P1	P2	P0	P1	P2	P0	P1	P2
SENS1	NATIONAL	29.9	6.3	1.9	21.4	3.9	1.1	13.0	2.2	0.6
	RURAL	30.6	6.5	2.0	22.9	4.2	1.2	14.1	2.4	0.6
	URBAN	26.5	5.6	1.8	13.9	2.5	0.7	7.4	1.2	0.3
	NATIONAL				-4.5%	-4.4%	-5.0%	-3.9%	-5.2%	-6.5%
	RURAL				-4.2%	-4.1%	-3.9%	-3.7%	-4.4%	-4.5%
	URBAN				-6.6%	-7.1%	-6.6%	-6.3%	-7.6%	-8.6%
SIM2	NATIONAL	29.9	6.3	1.9	21.5	4.0	1.1	13.0	2.2	0.6
	RURAL	30.6	6.5	2.0	23.1	4.3	1.2	14.1	2.4	0.6
	URBAN	26.5	5.6	1.8	13.8	2.4	0.7	7.2	1.2	0.3
	NATIONAL				-3.9%	-3.9%	-4.2%	-3.9%	-4.8%	-4.8%
	RURAL				-3.5%	-3.2%	-3.1%	-3.4%	-4.0%	-4.5%
	URBAN				-7.5%	-9.0%	-9.2%	-8.8%	-9.9%	-11.4%
SENS2	NATIONAL	29.9	6.3	1.9	21.8	4.0	1.2	13.2	2.2	0.6
	RURAL	30.6	6.5	2.0	23.3	4.3	1.2	14.4	2.4	0.7
	URBAN	26.5	5.6	1.8	14.3	2.6	0.7	7.7	1.3	0.3
	NATIONAL				-2.6%	-2.7%	-2.5%	-1.9%	-3.1%	-3.2%
	RURAL				-2.5%	-2.3%	-2.4%	-1.8%	-2.4%	-3.0%
	URBAN				-3.7%	-3.7%	-3.9%	-3.0%	-4.6%	-5.7%

Public investment in irrigation: food crops versus cash crops

Table 1c – Changes in return to factors

		Return to factors			
		Skilled agricultural labor	Unskilled agricultural labor	Irrigated land	Non-irrigated land
	2014/15	2.2%	-1.1%	-13.6%	0.0%
FC	2019/20	2.2%	-1.1%	-14.3%	0.0%
	2014/15	4.9%	-1.4%	-33.9%	0.0%
ALL	2019/20	4.8%	-1.5%	-33.9%	0.0%
	2014/15	2.9%	-0.4%	-23.7%	0.0%
CC	2019/20	2.8%	-0.4%	-23.2%	0.0%

Table 2c – Changes in value added

		Value Added (volume)				
		Agriculture	Manufacturing	Services	Agriculture Crops	Total economy
FC	2014/15	0.8%	0.0%	0.1%	1.1%	0.4%
	2019/20	0.8%	0.0%	0.1%	1.1%	0.4%
ALL	2014/15	1.5%	-0.1%	0.1%	2.1%	0.7%
	2019/20	1.5%	0.0%	0.1%	2.1%	0.7%
CC	2014/15	0.7%	-0.1%	0.0%	1.0%	0.3%
	2019/20	0.7%	-0.1%	0.0%	1.0%	0.3%

Table 3c – Changes in GDP at basic price and final demand

	Time	GDP_BP	GDP_FD	GDP_FD agriculture	GDP_FD manufacturing	GDP_FD services
FC	2014/15	-0.1%	-0.1%	-0.3%	-0.1%	0.1%
	2019/20	-0.1%	-0.1%	-0.3%	-0.1%	0.0%
ALL	2014/15	0.0%	0.1%	-0.2%	0.2%	0.2%
	2019/20	0.0%	0.0%	-0.2%	0.1%	0.1%
CC	2014/15	0.1%	0.1%	0.1%	0.3%	0.1%
	2019/20	0.1%	0.1%	0.1%	0.3%	0.1%

Table 4c – Changes in total and sectoral output

	Time	Output (volume)				
		Agriculture	Manufacturing	Services	Agriculture Crops	Total economy
FC	2014/15	0.8%	0.0%	0.1%	1.6%	0.3%
	2019/20	0.8%	0.0%	0.1%	1.6%	0.4%
SIM2	2014/15	1.3%	-0.1%	0.1%	1.8%	0.5%
	2019/20	1.3%	-0.1%	0.1%	1.8%	0.5%
CC	2014/15	0.5%	-0.1%	0.0%	0.1%	0.2%
	2019/20	0.5%	-0.1%	0.0%	0.1%	0.2%

Table 5c – Changes in intermediate demand price index

	Time	Intermediate demand price index	Intermediate demand Price index for agricultural commodities
FC	2014/15	-0.2%	-1.7%
	2019/20	-0.3%	-1.7%
ALL	2014/15	-0.2%	-2.4%
	2019/20	-0.3%	-2.5%
CC	2014/15	0.0%	-0.8%
	2019/20	0.0%	-0.8%

Table 6c – Changes in agricultural factors income

		agricultural labor income	land income	livestock income
FC	2014/15	-0.5%	-1.8%	-0.2%
	2019/20	-0.6%	-1.8%	-0.2%
ALL	2014/15	-0.4%	-3.6%	-0.3%
	2019/20	-0.4%	-3.5%	0.4%
CC	2014/15	0.2%	-1.9%	-0.2%
	2019/20	0.2%	-1.9%	0.6%

Table 7c – Changes in exports and imports

		Agriculture	Manufacturing	Services	Total
		Exports (volume)			
	2014/15	1.2%	-0.1%	-0.1%	1.0%
	2019/20	1.2%	0.1%	-0.1%	1.0%
		Imports (volume)			
	2014/15	-2.0%	0.2%	0.3%	0.1%
FC	2019/20	-2.0%	0.2%	0.3%	0.1%
		Exports (volume)			
	2014/15	3.6%	-0.3%	-0.4%	1.3%
	2019/20	3.6%	-0.2%	-0.4%	1.4%
		Imports (volume)			
	2014/15	-2.1%	0.3%	0.6%	0.3%
ALL	2019/20	-2.1%	0.3%	0.6%	0.3%
		Exports (volume)			
	2014/15	2.5%	-0.3%	-0.2%	0.9%
	2019/20	2.4%	-0.3%	-0.3%	0.9%
		Imports (volume)			
	2014/15	-0.2%	0.1%	0.3%	0.1%
CC	2019/20	-0.2%	0.1%	0.3%	0.1%

Table 8c – Changes in consumer price index

		Consumer price index				
	Time	Total	Agricultural commodities	Manufacturing commodities	Services	Agricultural food crops
FC	2014/15	-0.4%	-1.3%	0.0%	0.0%	-2.1%
	2019/20	-0.4%	-1.4%	0.0%	0.0%	-2.1%
ALL	2014/15	0.0%	-0.5%	0.2%	0.2%	0.0%
	2019/20	0.0%	-0.5%	0.2%	0.2%	0.0%
CC	2014/15	-0.5%	-1.6%	0.2%	0.3%	-2.1%
	2019/20	-0.4%	-1.8%	0.2%	0.2%	-2.2%

Figure 1c – Changes in food security index 3a and 3b, SIM2, FC, CC

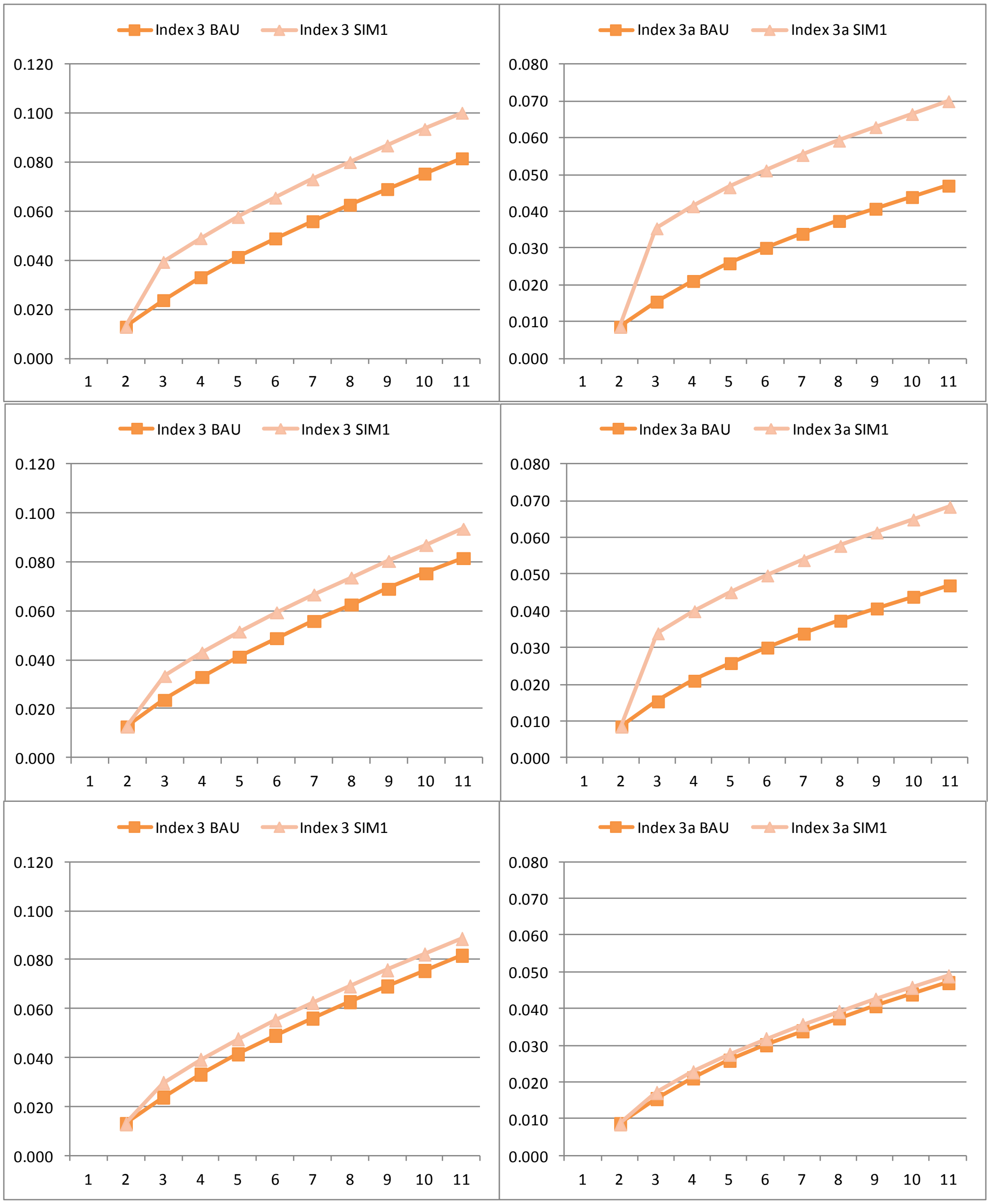

Table 9c – Changes in income by household type

	FC		ALL		CC	
Household income	2014/15	2019/20	2014/15	2019/20	2014/15	2019/20
Poor rural households	-0.4%	-0.4%	-0.3%	-0.3%	0.1%	0.1%
Non-poor rural households	-0.2%	-0.3%	-0.2%	-0.2%	0.1%	0.0%
Poor households in small urban settlements	0.2%	0.1%	0.4%	0.3%	0.3%	0.2%
Poor households in large urban settlements	0.1%	0.1%	0.4%	0.3%	0.3%	0.2%
Non-poor households in small urban settlements	0.2%	0.1%	0.5%	0.4%	0.3%	0.3%
Non-poor households in large urban settlements	0.1%	0.1%	0.4%	0.3%	0.3%	0.2%

Table 10c – Changes in FGT indices

		2009/10 (BAU)			2014/15			2019/20		
		P0	P1	P2	P0	P1	P2	P0	P1	P2
FC	NATIONAL	29.9	6.3	1.9	21.9	4.0	1.2	13.3	2.2	0.6
	RURAL	30.6	6.5	2.0	23.4	4.3	1.3	14.5	2.4	0.7
	URBAN	26.5	5.6	1.8	14.4	2.6	0.7	7.7	1.3	0.3
	NATIONAL				-2.1%	-2.2%	-2.5%	-1.3%	-2.6%	-3.2%
	RURAL				-1.9%	-1.8%	-1.6%	-1.2%	-2.0%	-1.5%
	URBAN				-3.4%	-3.4%	-2.6%	-2.4%	-3.8%	-2.9%
ALL	NATIONAL	29.9	6.3	1.9	21.5	4.0	1.1	13.0	2.2	0.6
	RURAL	30.6	6.5	2.0	23.1	4.3	1.2	14.1	2.4	0.6
	URBAN	26.5	5.6	1.8	13.8	2.4	0.7	7.2	1.2	0.3
	NATIONAL				-3.9%	-3.9%	-4.2%	-3.9%	-4.8%	-4.8%
	RURAL				-3.5%	-3.2%	-3.1%	-3.4%	-4.0%	-4.5%
	URBAN				-7.5%	-9.0%	-9.2%	-8.8%	-9.9%	-11.4%
CC	NATIONAL	29.9	6.3	1.9	22.1	4.1	1.2	13.4	2.3	0.6
	RURAL	30.6	6.5	2.0	23.7	4.4	1.3	14.5	2.5	0.7
	URBAN	26.5	5.6	1.8	14.5	2.6	0.8	7.8	1.3	0.3
	NATIONAL				-1.0%	-1.2%	-1.7%	-0.7%	-1.3%	-1.6%
	RURAL				-0.8%	-1.1%	-0.8%	-0.8%	-0.8%	-1.5%
	URBAN				-2.4%	-1.9%	-1.3%	-1.6%	-2.3%	-2.9%

Annex - SIM1, SIM2, SIM3

Table 1d – Food security index 3, 3a, 3b, 3c

Time	Index 3			Index 3a			Index 3b			Index 3c		
	BAU	SIM1	Change	BAU	SIM1	Change	BAU	SIM1	Change	BAU	SIM1	Change
1												
2	0.013	0.013	0%	0.009	0.009	0%	0.007	0.007	0%	0.006	0.006	0%
3	0.024	0.047	99%	0.015	0.048	211%	0.013	0.034	150%	0.010	0.037	268%
4	0.033	0.057	72%	0.021	0.054	157%	0.019	0.039	111%	0.013	0.041	203%
5	0.041	0.066	59%	0.026	0.059	129%	0.023	0.044	91%	0.016	0.044	171%
6	0.049	0.074	51%	0.030	0.064	113%	0.027	0.048	78%	0.018	0.047	152%
7	0.056	0.081	45%	0.034	0.068	102%	0.031	0.053	70%	0.020	0.049	140%
8	0.063	0.088	41%	0.037	0.072	94%	0.035	0.057	64%	0.022	0.051	131%
9	0.069	0.095	38%	0.041	0.076	87%	0.038	0.061	59%	0.024	0.053	124%
10	0.075	0.102	36%	0.044	0.080	82%	0.042	0.065	55%	0.025	0.055	118%
11	0.082	0.109	34%	0.047	0.084	78%	0.045	0.069	52%	0.027	0.057	113%
Time	Index 3			Index 3a			Index 3b			Index 3c		
	BAU	SIM2	Change	BAU	SIM2	Change	BAU	SIM2	Change	BAU	SIM2	Change
1												
2	0.013	0.013	0%	0.009	0.009	0%	0.007	0.007	0%	0.006	0.006	0%
3	0.024	0.039	66%	0.015	0.035	129%	0.013	0.026	96%	0.010	0.027	168%
4	0.033	0.049	48%	0.021	0.041	96%	0.019	0.032	72%	0.013	0.031	128%
5	0.041	0.058	39%	0.026	0.047	80%	0.023	0.037	59%	0.016	0.034	108%
6	0.049	0.066	34%	0.030	0.051	70%	0.027	0.041	51%	0.018	0.036	97%
7	0.056	0.073	31%	0.034	0.055	63%	0.031	0.045	46%	0.020	0.038	89%
8	0.063	0.080	28%	0.037	0.059	58%	0.035	0.049	42%	0.022	0.040	83%
9	0.069	0.087	26%	0.041	0.063	55%	0.038	0.053	39%	0.024	0.042	79%
10	0.075	0.094	24%	0.044	0.067	51%	0.042	0.057	36%	0.025	0.044	75%
11	0.082	0.100	23%	0.047	0.070	49%	0.045	0.061	34%	0.027	0.046	72%
Time	Index 3			Index 3a			Index 3b			Index 3c		
	BAU	SIM3	Change	BAU	SIM3	Change	BAU	SIM3	Change	BAU	SIM3	Change
1												
2	0.013	0.013	0%	0.009	0.009	0%	0.007	0.007	0%	0.006	0.006	0%
3	0.024	0.048	103%	0.015	0.048	211%	0.013	0.034	154%	0.010	0.037	271%
4	0.033	0.058	75%	0.021	0.054	157%	0.019	0.040	113%	0.013	0.041	205%
5	0.041	0.067	61%	0.026	0.059	130%	0.023	0.044	93%	0.016	0.044	173%
6	0.049	0.075	52%	0.030	0.064	113%	0.027	0.049	80%	0.018	0.047	154%
7	0.056	0.082	47%	0.034	0.068	102%	0.031	0.053	71%	0.020	0.049	141%
8	0.063	0.089	42%	0.037	0.073	94%	0.035	0.057	65%	0.022	0.051	132%
9	0.069	0.096	39%	0.041	0.076	88%	0.038	0.061	60%	0.024	0.053	125%
10	0.075	0.103	37%	0.044	0.080	82%	0.042	0.065	56%	0.025	0.055	119%
11	0.082	0.110	34%	0.047	0.084	78%	0.045	0.069	52%	0.027	0.057	114%

Tables 2d – Changes in labor and land income by household type

		Total capital income		Total labor income	
		2014/15	2019/20	2014/15	2019/20
SIM1	Poor rural households	0.1%	0.1%	-1.9%	-1.9%
	Non-poor rural households	0.3%	0.2%	-1.8%	-1.8%
	Poor households in small urban settlements	0.7%	0.5%	0.6%	0.4%
	Poor households in large urban settlements	0.7%	0.5%	0.6%	0.3%
	Non-poor households in small urban settlements	0.7%	0.5%	0.6%	0.3%
	Non-poor households in large urban settlements	0.7%	0.5%	0.6%	0.3%
		Total capital income		Total labor income	
		2014/15	2019/20	2014/15	2019/20
SIM2	Poor rural households	-0.2%	-0.2%	-0.3%	-0.3%
	Non-poor rural households	-0.1%	-0.2%	-0.3%	-0.4%
	Poor households in small urban settlements	0.6%	0.5%	0.6%	0.4%
	Poor households in large urban settlements	0.6%	0.5%	0.5%	0.4%
	Non-poor households in small urban settlements	0.6%	0.5%	0.5%	0.4%
	Non-poor households in large urban settlements	0.6%	0.5%	0.5%	0.4%
		Total capital income		Total labor income	
		2014/15	2019/20	2014/15	2019/20
SIM3	Poor rural households	-0.1%	-0.2%	-1.3%	-1.3%
	Non-poor rural households	0.0%	0.0%	-1.2%	-1.2%
	Poor households in small urban settlements	0.8%	0.6%	0.8%	0.5%
	Poor households in large urban settlements	0.8%	0.6%	0.7%	0.4%
	Non-poor households in small urban settlements	0.8%	0.6%	0.7%	0.4%
	Non-poor households in large urban settlements	0.8%	0.6%	0.7%	0.5%