INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

IFPRI

IFPRI Discussion Paper 01813

March 2019

NAIP Toolkit for Malabo Domestication

Economic Modeling of Agricultural Growth and Investment Strategy

Case Study of Kenya

Ismael Fofana

Miriam W. O. Omolo

Anatole Goundan

Lea V. Magne

Julia Collins

Estefania Marti

Africa Regional Office

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

The International Food Policy Research Institute (IFPRI), established in 1975, provides research-based policy solutions to sustainably reduce poverty and end hunger and malnutrition. IFPRI's strategic research aims to foster a climate-resilient and sustainable food supply; promote healthy diets and nutrition for all; build inclusive and efficient markets, trade systems, and food industries; transform agricultural and rural economies; and strengthen institutions and governance. Gender is integrated in all the Institute's work. Partnerships, communications, capacity strengthening, and data and knowledge management are essential components to translate IFPRI's research from action to impact. The Institute's regional and country programs play a critical role in responding to demand for food policy research and in delivering holistic support for country-led development. IFPRI collaborates with partners around the world.

AUTHORS

Ismael Fofana (i.fofana@cgiar.org) is a research fellow in the Africa Region of the International Food Policy Research Institute (IFPRI), Washington, DC.

Miriam W. O. Omolo (Miriam.omolo@apr-institute.org) is the director of programs at the African Policy Research Institute (APRI), based in Nairobi, Kenya.

Anatole Goundan (a.goundan@cgiar.org) is a research analyst in the Africa Region of IFPRI, Dakar Senegal.

Lea V. Magne (l.v.magnedomgho@cgiar.org) is a research analyst in the Africa Region of IFPRI, Dakar Senegal.

Julia Collins (j.collins@cgiar.org) is a research analyst in the Africa Region of IFPRI, Washington, DC.

Estefania Marti (e.marti@cgiar.org) is a research intern in the Africa Region of IFPRI, Washington, DC.

Notices

Contents

Tables

Figures

ABSTRACT

The Malabo Agenda on Accelerated Agricultural Growth and Transformation has brought technical challenges to the development of agricultural strategies by expanding the number of commitments and goals under the Comprehensive Africa Agriculture Development Programme. In this paper, we describe and apply an economic modeling framework that was developed to identify the agricultural investment priority areas for a country and to define milestones to track its progress towards the Malabo goals. The framework consists of a three-layer simulation model that aims to capture multiple Malabo commitments and goals. First, the agricultural productivity analysis uses the stochastic meta-frontier technique to assess opportunities to increase agricultural productivity. Second, the economywide analysis uses an agricultural and investment focused computable general equilibrium model to capture the Malabo goals on agricultural growth, intra-African trade of agricultural commodities, and public and private agricultural investments. Third, the microeconomic analysis builds upon statistical economic modeling to allow direct measurement and simulation of the Malabo goals on poverty and hunger. The modeling framework is applied to Kenya using the most recent data. The Malabo Agenda simulation results indicate that Kenya's current nonagriculture-led growth is not sufficient to achieving the Malabo overarching goals on poverty and hunger. Agriculture-led growth complemented by extended social assistance is more likely to close the income growth and inequality gaps and contribute to achieving the multiple Malabo commitments and goals by 2025.

Keywords: Economic Modeling, Agriculture, Growth, Poverty, Investment Prioritization.

ACKNOWLEDGMENTS

The authors thank Ousmane Badiane, Sam Benin, and Joseph Karugia for valuable comments and suggestions. The authors gratefully acknowledge financial support by the United States Agency for International Development (USAID).

ACRONYMS

AU	African Union
AUC	African Union Commission
AfDB	African Development Bank
BaU	Business as usual
CAADP	Comprehensive Africa Agriculture Development Programme
CES	Constant elasticity of substitution
CET	Constant elasticity of transformation
CGE	Computable general equilibrium
C.I.F	Cost, Insurance and Freight
DEA	Data envelopment analysis
ECA	Economic Commission for Africa
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
F.O.B	Free on Board
GAE	Government agricultural expenditure
GDP	Gross Domestic Product
IES	Income and Expenditure Survey
IFPRI	International Food Policy Research Institute
KIHBS	Kenya Integrated Household Budget Survey
KNBS	Kenya National Bureau of Statistics
MTE	Meta-frontier technical efficiency
MTIP	Medium-Term Investment Plan
NAIPs	National Agricultural Investment Plans
NASSEP	National Sample Survey and Evaluation Programme
NEPAD	New Partnership for African Development.
RECs	Regional Economic Communities
ReSAKSS	Regional Strategic Analysis and Knowledge Support System
SAM	Social Accounting Matrix
SAP	Status Assessment and Profile
SDGs	Sustainable Development Goals
SFA	Stochastic frontier analysis
TAPRA	Tegemeo Agricultural Policy and Analysis
TE	Technical efficiency
TGR	Technology gap ratio

1. INTRODUCTION

Poverty eradication and food security remain key development challenges in Africa. Poverty has been rising in Africa according to a recent report from the World Bank. The number of Africans living in extreme poverty has increased from 280 million in 1990 to 330 million in 2012 (Beegle et al. 2016). In 2016, 243 million people in Africa did not have access to sufficient food energy (FAO 2017). Moreover, the absolute number of undernourished and poor people is expected to grow given the current demographic changes, political contexts, and shifts in weather patterns (World Bank 2007). African political leaders recognize that addressing all the major economic and welfare challenges simultaneously will require an inclusive agricultural growth and transformation. Indeed, the Heads of State and Government of the African Union (AU) committed to agriculture-led growth, under the 2014 Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods (AU, 2014).

Under the Malabo Declaration, African leaders recommitted to the pursuit of agriculture-led growth and other principles and values of the Comprehensive Africa Agriculture Development Programme (CAADP). The Declaration upheld commitments to the key CAADP principles and targets of the 2003 Maputo Declaration, including achieving 6 percent annual agricultural growth and a 10 percent public agricultural expenditure share, while also laying out ambitious new goals to be achieved by 2025 (AU 2014). These include commitments to halve poverty, to end hunger, to double agricultural productivity, to reduce child stunting and underweight, to establish or strengthen public-private partnerships for priority agricultural value chains, to create agribusiness employment opportunities for youth and women, to triple intra-African agricultural trade, to increase the proportion of agricultural households that are resilient to climate risks, and to strengthen national, regional and continental mutual accountability processes.

Africa's agricultural development vision and goals are translated into institutional, policy, and investment actions through the design and implementation of evidence-based and Malabo compliant National Agricultural Investment Plans (NAIPs). The formulation of NAIPs is based on multi-stakeholder and multi-institutional approaches to ensure that African agricultural growth is inclusive and equitable, and to facilitate mutual accountability. It is important to ensure that NAIP formulation is sufficiently rigorous, includes country aspirations, and is consistent with the CAADP goals and commitments as stated in the Malabo Declaration.

This paper presents an analytical framework to technically address the political will expressed by the Malabo Declaration. The framework is centered on an economic modeling methodology which aims at informing and guiding countries in the design and implementation of evidence-based Malabo compliant NAIPs. More concretely, the framework builds coherence around the multiple goals and targets set by the Declaration. It defines the milestones to be reached to achieve the Malabo goals, which serve as a basis for the development of a Malabo compliant results framework. The analysis provides a set of actionable results to inform evidence-based NAIP program design. Furthermore, the analysis contributes to the identification and selection of the priority areas for public and private investments to achieve the Malabo goals and targets. The modeling tool is implemented using data from Kenya.

The rest of the paper is divided into five sections. Section 2 briefly discusses the strategic planning process underlying the analytical work. Section 3 presents the modeling tool used to set goals and milestones for the design and implementation of NAIPs. The scenarios for agricultural development are presented and discussed in section 4. The implementation of the modeling framework discussed in Section 5 gives an overview of Kenya's agricultural development status and profile and presents the results of the prospective analysis of Kenya's progress toward achieving the Malabo goals. The conclusion gives a synthesis of the lessons learned from the economic modeling and analysis of the implementation of the Malabo Agenda in Kenya.

2. STRATEGIC ECONOMIC PLANNING OF AGRICULTURAL DEVELOPMENT

By expanding the number of commitments and goals under CAADP, the 2014 Malabo Declaration brought challenges to the design and implementation of the NAIPs as compared to the 2003 Maputo Declaration. As key technical partners supporting the implementation of CAADP, the Regional Strategic Analysis and Knowledge Support System (ReSAKSS) and the International Food Policy Research Institute (IFPRI) began providing technical input to guide the development of post-Malabo NAIPs in 2016.

To address the challenges on the technical front, the goals and targets have been organized into two broader areas: overarching and thematic. The first covers the goals and targets on poverty, hunger, agricultural growth, and agricultural investments and financing. The second comprises six "thematic areas," including intra-Africa trade, inclusive growth and value chain development, food security and nutrition, gender, climate smart agriculture and resilience, and mutual accountability.

A strategic planning process became important to create coherence among the multiple commitments and goals. Moreover, creating a link between the Malabo overarching goals and targets and the actionable results guiding the NAIP is a crucial step toward ensuring evidence-based program design. This section gives an overview of a three-step analytical framework that supports the design of evidence-based and Malabo compliant NAIPs: Malabo Agenda domestication, agricultural development status analysis, and prospective analysis of agricultural development.

- *Malabo Agenda domestication*

Country processes start with the domestication of the Malabo Agenda. This first step consists of creating coherence between the country aspirations and vision for agricultural development and the Malabo commitments and goals. Given the highly heterogenous African economies, the NAIP is a country-specific process and an instrument to implement the continentwide agenda for agricultural transformation.

There are two levels of commitments relevant to the NAIP planning process: the supranational level (global, continental, and regional) and the national level. On the supranational level, the United Nations 2030 Agenda, also known as the Sustainable Development Goals (SDGs), replaced the 2015 Millennium Development Goals. The SDGs are a set of global goals that address urgent global economic, environmental, and political challenges to be achieved simultaneously by 2030. At the continental level, the African Union Commission (AUC) has been facilitating the implementation of the agricultural transformation agenda with the Malabo Declaration. Effective implementation and delivery on the Malabo goals should integrate the agenda of the SDGs and other international efforts. At the regional level, the Malabo Agenda is implemented by the Regional Economic Communities (RECs) to facilitate coordination and reporting. The RECs have established regional targets and collaboration mechanisms with their member states to accelerate and transform regional agricultures. At the national level, the NAIP is a unified framework that manages the country effort to develop the agricultural sector and to achieve its global, continental, regional and national commitments and goals. The country aspirations and vision of agricultural development are embedded in an overarching and multisectoral development framework (e.g. National Development Strategies). The NAIP provides a unique opportunity to create coherence among the multiple levels of commitments and goals by incorporating country goals as well as supranational (global, continental, and regional) shared prioritizes for agricultural transformation.

At the operational level, Malabo Agenda domestication is implemented through a national stakeholder convening events under the leadership of the government, the African Union Commission (AUC), and the Regional Economic Community (REC). At the Malabo domestication workshop, agricultural sector stakeholders discuss on the sector's long-term vision, objectives and priorities and develop a roadmap toward the development of a Malabo compliant NAIP—i.e., a NAIP designed to enable the country to meet the country's agricultural development goals and targets.

- *Agricultural Development Status Assessment and Profile*

The second step in the strategic planning process consists of conducting an agricultural development Status Assessment and Profile (SAP), providing a stocktaking of the country's agricultural landscape and its recent performance. The SAP reviews the changes which occurred in the country over the course of the first generation of NAIP and evaluates the country's current situation with respect to each of the Malabo overarching and thematic areas. It provides a baseline for the measurement of future progress towards targets. The SAP identifies clear metrics to measure targets and collects existing data to describe the country's status and profile. The analysis provides basic information on the country's agricultural landscape which serves as the base for the prospective analysis.

- *Prospective Analysis of Agricultural Development*

The third step of the strategic planning process provides an assessment of agricultural development prospects. This starts with the projection of the current state of business in the agricultural sector and the national economy and assesses the expected future outcomes against the Malabo goals and targets. The baseline projection, also called the "business as usual" (BaU) scenario, assumes continuity of the historical trends of the economy and the agricultural sector. In the event the conditions under the BaU are not satisfactory to achieving the Malabo goals by 2025, then the government would need to consider alternative development strategies to deliver on the Malabo commitments and goals, which are identified under the "Malabo scenario."

The prospective analysis of the agricultural development in line with the Malabo Agenda is the second part of the third step in the process. It lays out the necessary steps for a country to achieve the Malabo commitments and goals in the overarching and thematic areas. The analysis identifies the optimal level of investments and their most efficient allocation to deliver on the Malabo commitments and goals. Furthermore, specific actions, policies and institutional arrangement opportunities are identified for a country to successfully deliver on the Malabo Agenda. Thus, the current in-country practices are assessed against the existing best practices by thematic area, to identify the gaps and opportunities for improvement. This step provides guidance to the development of a Malabo compliant NAIP. It combines quantitative and qualitative analyses to address the various Malabo commitments and goals. The quantitative approach relies on economic modeling and simulation tools to assess the performance of the agricultural sector and the national economy, under various scenarios of the future.

The rest of this document focuses on the economic modeling tools of the third step of the analytical framework, which were developed to assess the Malabo overarching goals and milestones. It also includes and discusses the intra-Africa trade and the value chain development thematic issues. However, it does not cover the rest of the Malabo thematic areas - i.e. nutrition, gender, climate smart agriculture - at this stage of development of the modeling tool. Future expansion of the tool will progressively include the thematic issues.

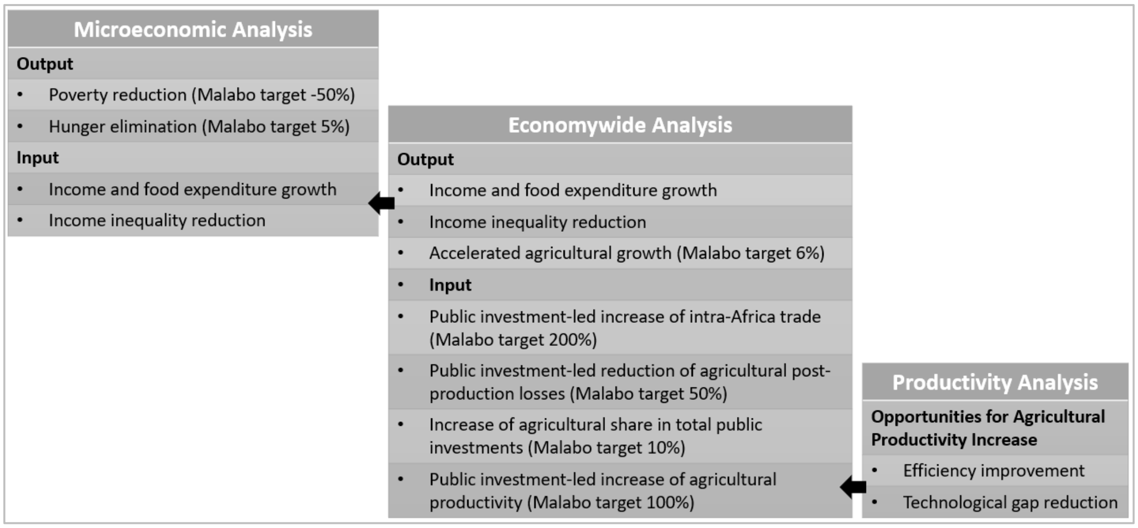
3. ECONOMIC MODELING OF THE MALABO AGENDA

Economic simulation models are practical tools to support evidence-based planning and implementation of agricultural development strategies. They help to establish a relationship between program inputs and expected outputs and outcomes and facilitate the prioritization of public interventions and investments. They have gained popularity because they allow the simulation of ex-ante impacts of strategies and policies. Two modeling techniques have been extensively used to assess agricultural development agendas: multimarket models (among others, Diao and Pratt, 2007; Johnson et al., 2013), and computable general equilibrium (CGE) models (among others, Benin et al., 2008; Breisinger, Diao, and Thurlow, 2009; Diao et al., 2012). The two approaches are preferred to farm-level production modeling because they include the demand response to changes in supply and, thus, capture changes in market prices.

Multimarket approaches are practical tools in a limited data environment. In addition, they capture the entire agricultural sector in detail. Although multimarket models have evolved to feature a general equilibrium setting, CGE models have been the preferred approach to assess agricultural growth and structural changes when the relevant data are accessible. CGE models capture relevant macroeconomic policies and features, such as Government fiscal policy, the current account balance, and the relationship between savings and investments. They include disaggregated nonagricultural sectors to better capture the backward and forward linkages of the agricultural sector and thus, the multiplier and economywide effects of changes occurred in the agricultural sector.

A three-layer economic modeling framework is built to assess the strategic options available to a country to achieve the Malabo commitments and goals. The framework consists of an agricultural productivity model, an economy wide general equilibrium model and a microeconomic model. The three models communicate through a set of interrelated variables linked in a sequential manner, that is, the output from one model is used as an input by another model (Figure 1).

Figure 1: Economic modeling framework



Source: Authors' illustration.

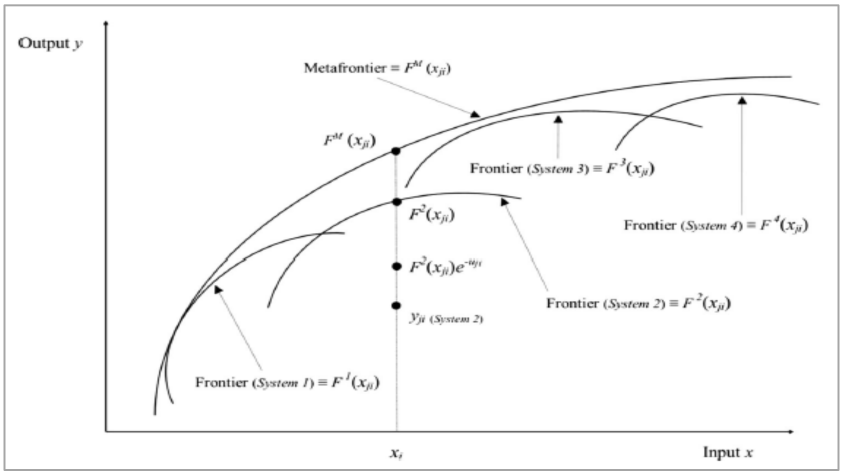
A mix of economic models is necessary to properly address the multiple Malabo commitments and goals. Thus, the microeconomic model addresses the Malabo goals and targets on poverty and hunger. However, the microeconomic model does not address issues related to economic growth, investments, and external trade as does the CGE model. Furthermore, the agricultural productivity analysis provides further insights not available in the first two models.

3.1 Agricultural Productivity Analysis

The agricultural productivity analysis is designed to address the Malabo goal on doubling current agricultural productivity levels. It provides useful information to the economywide modeling as it identifies the keys drivers of increases in agricultural productivity. According to Coelli, Prasada Rao and Battese (1998), there are four major methods used to analyze efficiency and productivity: econometric estimation of average response, index numbers, data envelopment analysis (DEA), and stochastic frontier analysis (SFA). The current analysis uses the stochastic frontier framework since it is the most relevant technique, including the assessment both of agricultural efficiency and of its drivers. In addition, with recent developments in stochastic frontier analysis, the meta-frontier framework can be used to compare different groups of farmers, for instant by agroecological zone (Battese and Rao, 2002).

Agricultural performance varies across farmers within and between groups depending on the technology used, the management skill, and the external conditions under which they operate. Thus, it is necessary to identify multiple production frontiers, that is as diversified as the farming system. Battese and Rao (2002) introduced the meta-frontier approach by estimating technical efficiency by group of famers and overall technical efficiency in the economy (Figure 2).

Figure 2: Meta-frontier production function with various production systems



Source: Melo-Becerra, Ligia Alba, and Antonio José Orozco-Gallo (2017).

Careful attention should be given when identifying the groups of famers because of the underlying assumption of similarity in the technology used by farmers in a given group. To apply the meta-frontier approach, it is important to test and validate the differences in efficiency among the preselected groups of farmers. The meta-frontier analysis starts with considering the groups of farms, thus the technologies, in the economy. The technical efficiency for each production unit, within farmers in a selected group, is assessed against the best technology among the selected group. To examine the performance of the farm relative to the overall economy, it is necessary to identify the meta-frontier by finding the function that best envelops the deterministic components of the estimated stochastic group frontiers.

The meta-frontier framework offers three indicators: technical efficiency (TE), technology gap ratio (TGR), and meta-frontier technical efficiency (MTE). All these indicators range between 0 and 1. The meta-frontier technical efficiency (MTE) measures the overall efficiency with regards to the meta-frontier for each unit of production and is comparable between farms from different technology groups. A score of 1 is equivalent to full efficiency. The MTE is decomposed into two parts: (1) the relative technical efficiency, TE; and (2) the gap between the farm specific technology and the metafrontier, TGR, expressed as the ratio of the meta-frontier to the group frontier. When the score of TE is 1, the selected farm or group of farms are said to be fully efficient regarding the adopted technology. A TGR score of 1 suggests that there is no gap to fill for the selected group with respect to the meta-frontier technology. In other words, the closer the TGR is to 1, the smaller the technology gap for the group under consideration regarding the economy modeled.

3.2 Economywide General Equilibrium Model

An agricultural investment focused computable general equilibrium (CGE) model is built to capture the agricultural sector-wide Malabo commitments and goals, i.e. agricultural output and productivity growth, intra-Africa trade of agricultural commodities, and public agricultural investments.

The CGE model is grounded in the Walrasian small open economy framework. That is profit-maximizing producers and utility-maximizing consumers interact under a competitive domestic pricing system which simultaneously determines quantities supplied and demanded. The economy is a price taker in world import and export markets. Although the core setting of the model builds upon the standard CGE framework,[1] the model includes some peculiarities related to the issue of agricultural transformation and investments and discussed in the next sections.

[1] Among others, Decaluwé et al. (2013) and Lofgren et al. (2002) propose standard archetypes of a single country CGE model.

- *Public and Private Investments*

Unlike most standard CGE models, our framework captures public and private investments separately. While the allocation of private investments across the economy is market-driven and follows the cost-benefit rule, public investment allocation is policy-driven and is set exogenously.

Private investment modeling follows the standard neoclassical framework as proposed by Jung and Thorbecke (2001). The model is saving-driven, that is, the level of aggregate private savings, from private domestic and foreign economic entities, conditions the level of private investment supply. The sector-specific investment demand is sensitive to the cost-benefit ratio of investment. The benefit of investment is measured by the return to capital. The cost of investment includes the sector specific capital use cost (or depreciation) set exogenously, and the opportunity cost of investment. The opportunity cost of investment is determined by the investment supply and demand clearance rule.

Public investment crowd in private investment by increasing total factor productivity and thus, increasing the return to private investment in a specific economic sector. Government saving and borrowing determine the aggregate level of public investment. Public investment is allocated across the economic sectors using a fixed proportionality rule. Sector-specific distributive shares are determined with respect to the Government initial (or BaU scenario) policy agenda.

- *Agricultural Productivity*

Three measures of productivity are captured by the CGE model: agricultural land (partial) productivity, agricultural labor (partial) productivity, and agricultural total factor productivity. Agricultural land productivity is measured by agricultural value added per unit of agricultural land used. A multi-layer nested production function which combines the production factors (i.e. agricultural land, other capital, and labor) and inputs (i.e. fertilizers, seeds, etc.) is specified for the agricultural sector. Land is activity-specific in the short-run.

Agricultural labor productivity is measured by agricultural value added per agricultural worker. Like agricultural land, agricultural labor constitutes one of the production factors in the multi-layer nested production function. Unlike land, labor is mobile across industries in the short run. Sector-specific labor demand is derived from the firm's profit maximization rule. Households' supplies of labor are fixed in the short run. The labor market generates excess labor supplies, including both unemployed and underemployed time. A wage-curve is used to specify the relationship between the wage rate and the excess labor supply rate.[2]

Unlike in most standard CGE models, total factor productivity (TFP) is endogenous, i.e. determined by the model. Thus, a relationship between an industry-specific level of TFP and the public and private capital stocks is established. Following Fofana, Badiane, Camara, and Goundan (2018), the relationship is sensitive to the private output elasticity of public capital stock. Three categories of Government expenditures are expected to impact agricultural TFP: expenditures to improve technical efficiency (e.g. skill development, information and extension service, etc.); expenditures to increase input use (e.g. high yield seeds, fertilizers, etc.); and expenditures to increase infrastructure (e.g. water management and irrigation). The empirical relationship between each category of expenditure and the private output is provided by the literature (Mogues, Fan, and Benin, 2015). The results of the meta-frontier agricultural productivity analysis discussed above contribute to selecting the relevant expenditures to be considered to achieve the Malabo goal on productivity growth.

- *Agricultural Post-Production Productivity*

Two types of agricultural post-production industries are captured by the CGE model, i.e. agricultural and food wholesale and retail trade services, and the food and beverage industry. When the data permits, each category can include several sub-industries; this is often the case for

[2] The wage curve, first introduced by David Blanchflower and Andrew Oswald (1989), empirically establishes a negative relationship between the unemployment rate and real wage levels.

the food and beverage industry but less likely for agricultural and food wholesale and retail trade services.

The Malabo goal of halving post-production losses is indirectly captured by the CGE model. We consider agricultural post-production TFP growth as an indirect measure of the reduction in agricultural post-production losses. In other words, an increase in public and private investments in agricultural post-production (i.e. equipment, machinery, and infrastructure) is likely to increase TFP and output, implying a reduction in post-production losses. A key milestone to achieving this goal is the increase in capital expenditures and output for the agricultural post-production industries relative to agricultural output.

- *Intra-African Trade of Agricultural Commodities*

The Malabo commitment and goal of tripling intra-African trade between 2015 and 2025 is captured by the CGE model. The model accounts for intra- and extra-African trade using a multi-layer nested constant elasticity of substitution (CES) specification for imports, and constant elasticity of transformation (CET) specification for exports. Thus, imperfect substitution between locally produced and foreign (African and non-African) commodities is assumed on the import side. Similarly, imperfect transformation between local and foreign markets is specified on the export side. The economy is an import and export price taker in both intra- and extra-African markets. However, infinite export demand elasticity (fixed Free On Board prices) is specified for extra-African markets, while finite export demand elasticity (flexible Free On Board prices) is applied to intra-African markets. The model includes a flexible real exchange rate while the current account balance, as a ratio to GDP, is kept constant.

- *Agricultural Growth*

The commitment to accelerate agricultural growth is a priority on the Malabo Agenda. The growth effect is captured through a sequential dynamic setting, in which consumers and producers are myopic optimizers. The model links multi-period static models through a dynamic (or between period) specification of the following economic variables: labor supply, land endowment, and private capital stock on the supply side, and government final consumption expenditure, household minimum consumption, and dividend distribution, on the demand side.

While labor demand is determined by the model, exogenous growth rates of labor supplies are applied. By selecting different growth rates for urban and rural labor supply based on historical trend, the model implicitly captures the rural-urban migration phenomenon. Agricultural land is activity-specific in the short run. However, its extension in the medium and long run depends on the return to agricultural land and the land price elasticity parameter. Private capital stock increases with private investment net of capital depreciation.

Government final consumption expenditure per capita is kept constant in real terms. Thus, total government final consumption expenditure, in constant prices, is updated between periods using the urban and rural population growth rates. This assumption is desirable as the model does not capture the socioeconomic implications of changes in government current expenditures. Similarly, households' minimum final consumption is updated between periods using the population growth rates. Dividends are distributed to investors (i.e. households, government, and the rest of the world) according to their shares in the investments. The initial shares given by the Social Accounting Matrix (SAM) are adjusted between periods using savings information. Households and firms save fixed proportions of their income. Government saving is residual after accounting for spending on goods and services for final consumption, and on transfers to other agents. Foreign saving is kept fixed as a ratio of the economywide GDP.

- ***Income Growth and Distribution***

Households' income is generated from factor payments, i.e. salaries and wages, the return to capital, and the return to land, and from transfers, i.e. dividends and other transfers. Income growth and distribution is closely related to the factor endowment and factors' economic rewards. Therefore, the model includes various categories of factors and households to better capture the income distribution and the change in income inequality across the population.

Households are split up by residential area, i.e. urban and rural, and by household final consumption expenditure quintile in each residential area. The separate household categories allow the measurement of income growth at national, urban, and rural levels and across the quintile categories to facilitate the assessment of income growth and inequality and, therefore, the link with the microeconomic model.[3]

3.3 Microeconomic Model

The goals of halving poverty between 2015 and 2025 and ending hunger by 2025 are directly assessed using a microeconomic model. Poverty and hunger are measured at the individual or household level and use micro level information, i.e. nationally representative survey data.[4] A given level of poverty is associated with an income level and its distribution across the population. Thus, income inequality is an important determinant of poverty and hunger results. The microeconomic model captures changes in income distribution and inequality measures across the population.[5]

Microeconomic models are designed to predict individuals' reactions to a policy shock when facing different economic and institutional environments or constraints. They are useful in integrating the heterogeneous behavior of economic agents and accounting for the aggregate costs and benefits of an intervention or shock (Bourguignon and Spadaro, 2006). There are multiple approaches to conducting a microsimulation under a CGE framework and the choice among these approaches depends on data availability, the research question and time constraints (Cockburn, Savard, and Tiberti 2012).

In terms of the modeling of individual behavior responses, microsimulation models can be grouped into parametric behavioral approaches (e.g. Bourguignon, Robillard and Robinson,

---

[3] When the data permit, the macro and micro models can also be linked through the factor markets to capture the change in individual-level earnings as suggested by Bourguignon and Spadaro (2006). Cockburn, Savard and Tiberti (2014) discuss the various approaches to link micro and macro models.
[4] Surveys conducted under the Living Standard Measurement Study (LSMS) of the World Bank and similar surveys are used to estimate the poverty and hunger measures.
[5] The use of the growth-to-poverty elasticity parameter (Thurlow, Kiringai, and Gautam 2007) does not capture the changes in income inequality.

2005) and non-parametric approaches (e.g. Vos and Sanchez, 2010). Parametric behavioral approaches include parameters estimated from survey data using econometric techniques. In general, they capture the distribution of earnings through labor market participation and consumption choices based on individual characteristics and those of the household and community the individual belongs to. Nonparametric approaches are applied to labor market participation and distribution of earnings using a randomized process to determine the resulting change in labor force status. The comparison between the parametric behavioral approach and the non-parametric approach conducted by Debowicz (2016) in Argentina indicates that the distributional results of both models are consistent with the data. Since the non-parametric approach is less demanding in terms of data requirements but produces similar results, it is advisable to use the non-parametric approach to capture the micro impact of macro shocks when time and data are limited (Debowicz, 2016).

We use the reweighting approach, pioneered by Meagher (1993) and latter applied, among others, by Devarajan and Go (2001) in Zambia, Ferreira and Horridge (2006) in Brazil, Herault (2010) in South Africa, and Fofana, Chitiga-Mabugu and Mabugu (2018) in South Africa, to assess the goals and milestones for income growth and distribution to achieve the Malabo goals on poverty and hunger. Our approach captures income distribution and consumption behavior changes across the population based on the estimation of the income probability distribution as proposed by Lee and Judge (1996). Unlike previous reweighting analyses conducted at the household level, our simulation is performed at the individual level. Thus, a statistical economic model is built to capture the changes in the probabilities associated with individual income levels induced by changes in mean (per capita) income through a “generalized entropy” measure. When the data permit, the model also captures changes in individuals’ factor earnings, i.e. labor categories, land and other capital. Our approach assumes that all possible individual-level income earnings and the related consumption behavior are observed in the survey. The probabilities associated with each income quantile are expressed through weights assigned to each surveyed individual. Macro shocks, i.e. changes in average income, are simulated by adjusting individual-level weights, implying a change in income distribution and consumption behavior at the population level. Thus, the approach implicitly includes individuals' behavioral change as they move from one income level to another. The model captures aggregate outcomes from individuals' income and consumption behavioral changes but does not produce individual-level information on transition to a different income level. Therefore, the approach is blind in identifying the winners and losers of a macro shock (Herault, 2010). Herault (2010) compared results from the parametric behavioral approach and the reweighting approach applied in South Africa. The two approaches provided similar findings, although the reweighting approach tends to introduce a "small bias in the results without modifying the main conclusions."

The poverty measures use the money metric approach of Foster, Greer and Thorbecke (1984). The poverty measures used in this study refer to the poverty headcount index, which measures the proportion of the population under a given poverty line. Both the national and the international poverty lines can be used to measure the poverty headcount index.

Constructing the poverty line requires specifying a consumption bundle considered adequate for basic food and non-food consumption needs, and then estimating its cost. The standard technique of measuring hunger is to compare the number of calories eaten by a person with the number of calories needed.[6] Thus, the study compares the individual food expenditure to a threshold representing the cost of adequate basic food to measure the hunger index. The terms hunger index and food poverty index are used interchangeably hereon.

Poverty and hunger levels are measured directly and require a nationally representative Income and Expenditure Survey (IES). The survey is also used to calibrate the microeconomic model. A calibration procedure is used to assess whether the model is consistent with predetermined structures observed in the data. The calibration utilizes the growth elasticity of

[6] Statistics South Africa defines the food poverty line as "the rand value below which individuals are unable to purchase or consume enough food to supply them with the minimum per-capita-per-day energy requirement for adequate health" (Statistics South Africa, 2017). The food poverty index estimates the percentage of persons vulnerable to hunger and, therefore, facilitates the measurement of hunger (Statistics South Africa 2017).

poverty (Bourguignon 2003) and Engel's law. The growth elasticity of poverty is the percentage change in poverty associated with a one percent change in income per capita. Engel's law refers to the decrease in the percentage of income allocated to food purchases associated with an increase in total income. During the calibration procedure, we assess whether the model provides results consistent with Engel's law and with empirically observed values of the growth elasticity of poverty.

4. SCENARIOS FOR AGRICULTURAL DEVELOPMENT

This section assesses and discusses the prospects for agricultural development implemented by the analytical framework discussed in the previous sections. The discussion here built upon two scenarios for agricultural development. The first scenario is the continuity of the historical trends of the economy, including the agricultural sector, referred to as the Business as Usual (BaU) scenario. The second scenario simulates the successful implementation of the Malabo Agenda on accelerated agricultural growth and transformation and the achievement of the Malabo goals and targets, referred to as the Malabo scenario.

- **The Business as Usual Scenario**

The BaU scenario projects the 2011–2015 performance of the economy. The scenario assumes the economy is not subject to any major shock or policy shift over the period 2015–2025. In the first step, the scenario is implemented by the economywide model. The baseline simulation results must be consistent with the past trends of the country's economy performance, including the agricultural sector as presented by the agricultural development Status Assessment and Profile (SAP).

In the second step, the results from the economywide simulation are imposed in the microeconomic model. Thus, the microeconomic model uses the projected income growth and distribution across the household categories suggested by the economywide model. We use household final consumption expenditure to measure income. In addition to the income growth and distribution information, the microeconomic model uses population growth and urbanization prospects from the United Nations (2017) to assess the poverty and hunger outcomes.

- **The Malabo Agenda Scenario**

The Malabo scenario is also implemented in two steps. First, by the microeconomic model to assesses the required income growth and distribution to achieve the Malabo goals on poverty and hunger. Second, the microsimulation results are passed on to the economywide model to assess the investment and growth requirements to achieve the Malabo goals on poverty and hunger. A public investment-led growth, with a focus on agricultural selected commodities and value chains, is simulated by the economywide model.

The economic modeling captures three levels of results as presented by the CAADP Results Framework (2015) and depicted by Graph 1. The first level presents the outcome results on the overarching poverty and hunger goals. The achievement of these goals requires shared income growth and increased food consumption expenditures as milestones. The second level covers the output results on accelerated growth and transformation of agriculture. The results at this level are achieved with other Malabo goals. They include doubling agricultural productivity, investing in agricultural post-production activities to halve agricultural post-production losses, tripling the intra-African trade of agricultural commodities, and increasing the consumption of locally produced food items. The milestones defined for each sector-wide goal are discussed in section 5. The third level identifies the various areas of investment to trigger the results chain and simultaneously achieve the multiple Malabo goals and targets.

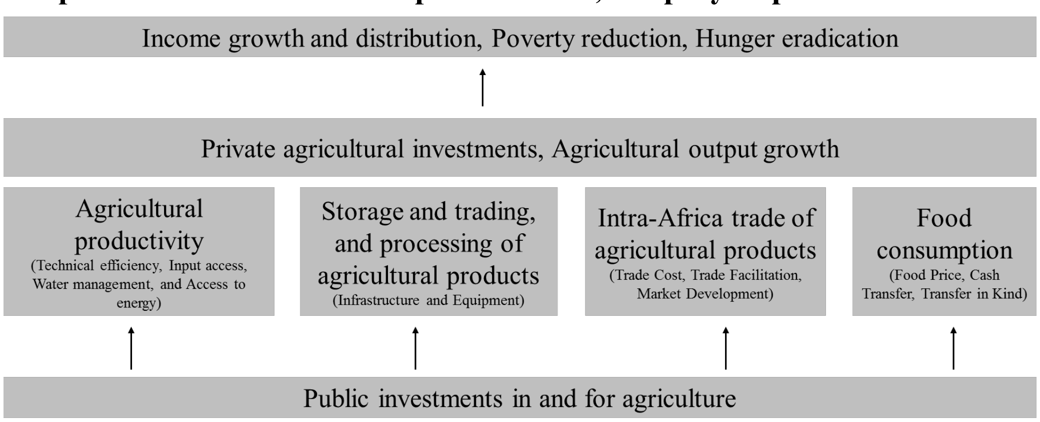
The productivity increase goal is linked to three key milestones, i.e. improving agricultural technical efficiency (i.e. skill development, and increasing information and extension services), increasing access to affordable input in agriculture (i.e. high-yield seeds, fertilizer, and other input), and increasing agricultural infrastructure (i.e. water management and irrigation). Public spending is directly associated with each option to achieve the Malabo goal on productivity. The results from the agricultural productivity analysis discussed in section 3 (i.e. Agricultural Productivity Analysis) are useful in guiding the selection of the relevant options for a country.

A target of increasing total factor productivity in agricultural post-production, i.e. storage and trading, and processing of agricultural products, by 50 percent is used as a proxy for the Malabo goal of halving post-production losses. An increase in public and private investments in agricultural post-production industries is likely to positively impact total factor productivity and reduce post-production losses. Thus, in the Malabo scenario, public investment is increased in agricultural post-production industries, i.e. food processing and domestic trading, to meet the target of 50 percent increase in post-production total factor productivity.

The Malabo goal of tripling intra-African trade in agricultural and food commodities uses two milestones: the reduction of intra-African trade costs and the facilitation of intra-African trade.[7] The cost reduction intervention is implemented through the changes in import and export domestic prices. The facilitation intervention is captured through changes in trade elasticity values compared to the BaU scenario. It assumes that the Malabo scenario allows more flexibility to consumers to tradeoff between locally produced products and African imports for agricultural and food commodities. In the same vein, producers are given more flexibility to sell agricultural commodities on the domestic market or the African market.

The Malabo goals and milestones of reducing income inequality, increasing access to locally produced food items and ending hunger are captured by the economywide model. Food price subsidy (universal instrument) and/or cash transfer (targeted instrument) are implemented to achieve these goals.[8] The interventions are captured through changes in consumer prices and/or household net income, respectively.[9]

Graph 1: Malabo Scenario Implementation, Simplify Representation



[7] Although not implemented here, market development or increase export demand scenario is accommodated by the model.

[8] Transfer in kind (i.e. food voucher) is another intervention that can be implemented along with the price subsidy and the cash transfer interventions.

[9] The model only includes the direct cost of implementing these interventions. The administrative and managerial costs (indirect cost) are not included.

5. IMPLEMENTATION OF THE MODELING FRAMEWORK: THE CASE STUDY OF KENYA

The implementation of the modeling framework requires the use of country level macro and micro datasets. The required datasets for the modeling work are discussed in this section. Furthermore, the implementation of the model also relies on a stocktaking of the current performance of the agricultural sector and the national economy in general. This information defines the baseline or reference scenario to be compared against alternative scenarios for agricultural development. The baseline information is provided by the presentation of Kenya's agricultural development status. Finally, the section presents and discusses the simulation results for an alternative scenario for agricultural development, i.e. the Malabo scenario.

5.1 Data Requirement

The Kenya Integrated Household Budget Survey (KIHBS) collected by the Kenya National Bureau of Statistics (KNBS, 2018) is used to implement the microeconomic model. The 2015/16 KIHBS sample was drawn from the fifth National Sample Survey and Evaluation Programme (NASSEP V) household sampling frame. A sample of 24,000 households was drawn from the 2009 Kenya Population and Housing Census enumeration areas. The frame is stratified into rural and urban residential areas within each of the 47 counties, making it representative at the national level. Thus, a total of 23,852 households were sampled. Finally, 21,773 households were interviewed with 8,861 in urban areas and 13,092 in rural areas. The field data collection was conducted from September 2015 to August 2016. The survey provides a wide range of socioeconomic indicators, including data on demographics, education, health, household consumption, expenditure patterns, and source of household income.

The CGE model is implemented using a Social Accounting Matrix (SAM). A SAM is a square matrix that describes the transaction flows taking place within an economy during a given period of time (Fofana, Diallo, Sarr, and Diouf, 2015). The CGE model is implemented using the 2013 SAM for Kenya (Randriamamonjy and Thurlow, 2017). The SAM describes 54 industries, including 21 agricultural industries; 56 commodities, including 21 agricultural commodities; 8 food processing, beverage and tobacco industries and commodities; 1 account for trade and transportation margins; 3 accounts for production factors; and 8 institutional accounts, including 4 tax accounts and 1 account for the rest of the world. We use the 2015/16 KIHBS and other databases to break down:

- The household account by residential area (i.e. rural and urban) and by household final consumption expenditure quintile categories,
- The external trade with the rest of the world into African and non-African trade,
- The labor account into rural and urban labor categories, and the latter into three skill categories: low skilled, medium skilled, and high skilled labor,
- The trade and transportation margins into those for agricultural and food products and those for other products.

The meta-frontier framework is implemented using household survey data collected in 2010 under the Tegemeo Agricultural Policy and Analysis (TAPRA) project. A total of 1,309 households were surveyed across the agroecological zones of rural Kenya. Two harvest seasons were covered by the survey, i.e. the main season and the short season. Thus, we analyzed farm efficiency at the field and harvest season level. Since each household may have more than one fields in each season, the final sample size is approximatively 8,715 fields with 2,774 observations for the short season and 5,941 observations for the main harvest season.

5.2 Overview of the Kenya Agricultural Development Status Assessment and Profile

The discussion of Kenya's status and progress on the Malabo metrics in this section relies primarily on an assessment carried out for Kenya by Benin et al. (2016). The assessment compares the state of the metrics before and during the implementation of Kenya's agricultural sectoral development strategy, the Medium-Term Investment Plan (MTIP), which covered the period of 2010–2015.[10] It does not account for uneven performance triggered by crises that have occurred before and during MTIP implementation. The average level during the period of the MTIP is compared to a baseline measurement showing average values during a reference period.

- *Agricultural Investment and Growth, and Poverty Reduction*

The status and progress assessment of the Malabo overarching commitments and goals primarily uses metrics identified in the Comprehensive Africa Agriculture Development Programme (CAADP) Results Framework. Annex B presents the detailed results of the assessment. The government agricultural expenditure (GAE) growth rate increased during MTIP implementation compared to the reference period (Table 1). The declining annual growth rate of -1.6 percent on average during the reference period of 2003–2007 was reversed during the MTIP implementation period of 2010–2014 to reach 5.6 percent. However, GAE as a share of total expenditures stagnated around 4 percent before and during the MTIP period. GAE remained below the 10 percent CAADP target during the MTIP period. A similar trend is observed in spending intensity, i.e. GAE relative to agriculture value added; the ratio increased slightly from 3.3 to 3.9 percent before and during the MTIP period.

[10] The status assessment considers the period 2010-2014 as the implementation period due to lack of data availability.

Table 1: Kenya's change in agricultural investment and financing (%)

	Reference	MTIP
Government agriculture expenditure growth rate (%)	-1.6	5.6
Government agriculture expenditure (% of total government expenditure)	3.8	4.0
Government agriculture expenditure (% of agriculture value added)	3.3	3.9

Source: Benin et al. (2016);
Note: Reference period: 2003–2007. MTIP period: 2010–2014.

Agricultural value added per agricultural worker and per hectare of arable land were 39.5 and 50.3 percent higher on average during the MTIP period compared to the reference period (Table 2). Yields of major crops declined or slightly increased between the two periods, except cassava, which showed a higher yield increase. This has led to a small increase in total agricultural production between the reference and the MTIP periods. The growth rate of agricultural value added increased from 3.6 percent per year on average during the reference period to 4.8 percent per year on average during the MTIP period. Thus, the agricultural growth rate was below the CAADP target of 6 percent during the MTIP period.

Table 2: Kenya's agricultural productivity and output growth

	Reference	**MTIP**
Agriculture value added per agricultural worker (constant 2005 USD)	360	503
Agriculture value added per hectare of arable land (constant 2005 USD)	824	1,238
Yield for individual crops (Ton/Ha)		
Wheat	2.5	2.6
Cassava	9.0	11.4
Sugar cane	86.5	76.7
Coffee green	0.3	0.3
Tea	2.3	2.1
Growth rate of output for individual commodities (%)		
Wheat	1.6	25.1
Cassava	5.1	15.8
Sugar cane	3.1	3.2
Coffee green	1.0	-5.6
Tea	5.5	9.1
Agriculture production index (2004–2006=100)	99.1	121.1
Agriculture value added (Billion US$)	4.9	13.1
Growth rate of agricultural value added (constant 2005 US$)	3.6	4.8

Source: Benin et al. (2016);
Note: Reference period: 2003–2007. MTIP period: 2010–2014.

The per capita agricultural value added average annual growth rate increased from 0.9 percent during the reference period to 2.1 percent during the MTIP period (Table 3). Similarly, the GDP average annual growth rate accelerated from 2.7 percent prior to MTIP to 3.2 percent during MTIP. Although significant progress was made in the agricultural sector, economywide growth continued to be led by non-agricultural sectors. The number of jobs created per year increased by 17.8 percent between the reference and MTIP periods, leading to a slight increase in the average employment rate from 54.0 to 55.4 percent before and during the MTIP period.

Table 3: Change in Kenya's agriculture value added, employment, income growth and inequality, annual average (%)

	Reference	MTIP
Growth rate of agricultural value added per capita (constant 2005 US$)	0.9	2.1
Growth rate of GDP per capita (constant 2005 US$)	2.7	3.2
GDP per capita (constant 2005 US$)	526.9	617.1
GNI per capita, PPP (constant 2011 international $)	2,271.1	2,670.1
Gini coefficient	48.5	
Number of jobs created per annum	614,190	723,355
Employment rate (% of population)	54.0	55.4

Source: Benin et al. (2016);
Note: Reference period: 2003–2007. MTIP period: 2010–2014.

According to the report on well-being in Kenya published by the Kenya National Bureau of Statistics (KNBS 2018), 36.1 percent of the population, an equivalent of 16.4 million individuals, fell under the overall national poverty line in 2015.[11] Poverty has declined between 2005 and 2015 both in relative and absolute terms according to the same report (Table 4). In addition, 32.0 percent of the population, an equivalent of 15.6 million individuals, fell below the food poverty line in 2015.[12] Like the overall poverty, food poverty has also declined between 2005 and 2015. Furthermore, Kenya has achieved higher reduction of food poverty compared to overall poverty. Poverty remains a rural phenomenon in Kenya, the rural population represented 64.1 percent of the total population and accounted for 71.3 and 71.7 percent of the total number of persons below the overall and food poverty lines respectively in 2015. The rural contribution to overall poverty dropped slightly by 0.9 percent between 2005 and 2015. In contrast, the rural contribution to food poverty increased by 2.4 percent over the same period. Although growth has

[11] The estimation uses the Kenya Integrated Household Budget Survey (KIHBS) 2015–2016 and the poverty line for rural and urban areas respectively of Ksh 3,252 and Ksh 5,995 per month in adult equivalent.

[12] The food poverty line was set at Kshs 1,954 and Kshs 2,551 per month in adult equivalent for rural and urban areas, respectively.

contributed to reducing poverty both in rural and urban areas in Kenya, its distribution was unfavorable to the poor in rural areas.

Table 4: Kenya's overall poverty and food poverty estimates in 2005/06 and 2015/16

Poverty Line	Year	National		Rural	
		Headcount Index (%)	Number of individuals (Million)	Headcount Index (%)	Number of individuals (Million)
Food	2015/16	32.0	14.5	35.8	10.4
	2005/06	45.8	16.3	49.5	11.3
Overall	2015/16	36.1	16.4	40.1	11.7
	2005/06	46.6	16.6	52.5	12.0

Source: KNBS (2018).

- *Inclusive Growth and Value Chain Development*

The challenge in establishing baseline values for the inclusive growth and value chain development metrics is the availability of and accessibility to secondary data. This section relies on agricultural variables that are currently available from international databases, primarily the FAOSTAT database of the Food and Agriculture Organization of the United Nations (FAO) and the World Development Indicators database of the World Bank. In this section, we identify and discuss the top strategic commodities in terms of value of production and contribution to caloric intake in the diet.

The food consumption data are based on the FAO Food Balance database for the most recent year available. Data on the area, production and yield of crops is based on the FAO Crop Production database, taking the average of 2009–2011 in view of the weather-related volatility of these statistics. Table 5 shows the top five food items in Kenya in terms of contribution to caloric intake in the diet. Maize is the most important staple food, accounting for 31 percent of total caloric intake. Wheat, milk, sugar, and beans are also in the top five. Together, they represent 63 percent of the caloric intake of the Kenyan population. Kenya is one of the few African countries with a large wheat growing sector, although domestic production is supplemented by imports. The appearance of milk as one of the five most important food items in the diet reflects the unusually large and dynamic dairy sector in Kenya.

Table 5: Food items in Kenya ranked by caloric contribution to the diet

Food item	Caloric intake (kcal/day/person)	(percent)
Maize	671	30.9
Wheat	255	11.7
Milk	173	8.0
Sugar	152	7.0
Beans	115	5.3
Other	-	37.1
Total	-	100.0

Source: Benin et al. (2016).

Maize is also the most important crop in terms of the value of production, as shown in Table 6. On the other hand, the other top crops in production value (potatoes, bananas, tea, and mangoes) do not appear in the top five by caloric intake. Tea is a major export crop, and mango exports have been expanding rapidly in recent years, although most mangoes are produced for domestic consumption. Potatoes and bananas are produced primarily for domestic consumption.

Table 6: Crops in Kenya by value of production

Crop	Value of crop production (US$ million)	Share of the value of crop production (percent)
Maize	491	12
Potatoes	460	11
Bananas	446	11
Tea	424	10
Mangoes	332	8
Other crops	1,942	47
Total	4,095	100

Source: Benin et al. (2016).

The area, yield, and production of the five most valuable crops in Kenya are shown in Table 7. Maize is grown on over 2 million hectares in Kenya, reflecting its status as the main staple crop in the country. Its yield is 1.5 t/ha, resulting in production of about 3 million tons of grain. Tea is grown on less than 0.2 million hectares and has a yield of 2.1 t/ha, resulting in a harvest of 363 thousand tons. It maintains a place among the five most valuable crops because of its high unit value. Potatoes, bananas, and mangoes are grown on even smaller areas, but have much higher yields, ranging from 14 t/ha for mangoes to almost 21 t/ha for bananas.

Table 7: Production of major crops in Kenya

Crop	Harvested area (1000 ha)	Yield (t/ha)	Production (1000 t)
Bananas	72.21	20.68	1,489.35
Maize	2,008.20	1.53	3,093.47
Mangoes	36.82	14.02	512.46
Potatoes	121.73	20.24	2,463.43
Tea	172.69	2.11	363.71

Source: Benin et al. (2016).
Notes: ha = hectare; t = ton

Table 8 shows the yield trends of the five most valuable crops in Kenya. Bananas, mangoes, and potatoes show a clear trend toward increasing yields over the past 15 years, but maize and tea do not show any apparent trends.

Table 8: Yield trends for major crops in Kenya

Year	Bananas	Maize	Mangoes	Potatoes	Tea
2000	13.83	1.44	7.49	6.18	1.96
2001	13.98	1.70	10.86	9.16	2.37
2002	13.73	1.51	10.59	7.71	2.18
2003	12.81	1.62	7.50	9.67	2.23
2004	12.68	1.93	7.38	8.44	2.37
2005	15.00	1.64	14.33	20.00	2.32
2006	15.00	1.72	11.69	20.00	2.11
2007	15.00	1.81	16.42	20.00	2.48
2008	20.38	1.39	17.70	21.48	2.19
2009	24.14	1.29	14.57	19.12	1.98
2010	18.97	1.73	15.99	22.43	2.32
2011	18.93	1.58	11.51	19.17	2.01
2012	23.97	1.74	11.88	20.34	1.94
2013	23.24	1.69	12.36	14.43	2.18
2014		1.66		14.07	

Source: Benin et al. (2016).

- *Intra-African Trade of Agricultural Commodities*

This section assesses the changes in the intra-African trade position of Kenya before and during MTIP implementation. It focuses on changes in intra-African exports and imports for agricultural and food commodities. The latter are differentiated into seventeen groups, including staple food and cash commodities. The analysis also covers an assessment of the importance of African markets versus non-African markets as destinations for exports and as origins of imports for the selected agricultural commodity groups. Kenya participates in intra-African trade both as an exporter and an importer of most agricultural commodities (Table 9). Average export values exceed import values, making Kenya a net exporter of agricultural commodities in African markets before and during MTIP. Comparing the ratio of exports to imports of agricultural commodities, Kenya's net export position eroded during MTIP compared to the previous period.

When different commodity groups are taken under consideration, Kenya's trade position in African markets is more nuanced (Table 9). Before MTIP, the country was a net exporter primarily of coffee and tea, edible oils, vegetables, and live trees and plants, in the sense that these products were exported to African markets in higher values than they were imported from the same markets. Still, the country was a net importer of many other commodities including, most notably, cane or beet sugar, cereals, fish and animal products, and edible fruits and nuts. The country's net trade position in African markets has been kept unchanged between the periods before and during MTIP for all commodities, except for live trees and plants and vegetables, for which Kenya has moved from a net exporter to a net importer position in African markets.

Table 9: Change in Kenya's intra-African agricultural trade performance

	Reference			MTIP		
	Export (Average trade value, US$ 1000)	Import (Average trade value, US$ 1000)	*Exports-to-Imports Ratio*	Export (Average trade value, US$ 1000)	Import (Average trade value, US$ 1000)	*Exports-to-Imports Ratio*
Live animals	463	100	*4.6*	4177	620	*6.7*
Fish & animal products	2583	12433	*0.2*	21702	24741	*0.9*
Roots & tubers	19	9	*2.1*	198	27	*7.3*
Live trees and plants	2749	1402	*2.0*	3628	4864	*0.7*
Vegetables	3786	2011	*1.9*	11101	30614	*0.4*
Edible fruits & nuts	537	2392	*0.2*	1723	20341	*0.1*
Coffee & tea	107952	50499	*2.1*	292141	139312	*2.1*
Spices	751	261	*2.9*	3007	1664	*1.8*
Cereals	5915	17757	*0.3*	10475	67562	*0.2*
Oilseeds	579	597	*1.0*	368	15029	*0.0*
Edible oils	24446	867	*28.2*	66847	7467	*9.0*
Cane or beet sugar	5535	36845	*0.2*	895	86465	*0.0*
Cocoa beans	2	22	*0.1*	1	125	*0.0*
Hides & skins	511	645	*0.8*	570	3850	*0.1*
Cotton, not carded or combed	138	1504	*0.1*	24	1023	*0.0*
Cotton, carded or combed	103	2615	*0.0*	57	5035	*0.0*
Other agricultural products	62412	26355	*2.4*	256361	147189	*1.7*
Agriculture	218410	156302	*1.4*	673229	555915	*1.2*

Source: Benin et al. (2016).
Note: Reference period: 1998–2003. Due to data availability, the MTIP years are here restricted to 2010–2013 although the Plan covers the period 2010–2015.

Prior to MTIP, African markets were the destinations of 16.7 percent of Kenya's global agricultural exports and origins of 29.0 percent of the country's global agricultural imports (Table 10). In other words, Kenya's participation in African agricultural markets was weak compared to its participation in non-African markets of agricultural products. During MTIP, African markets have gained more importance as destinations of Kenya's exports of agricultural products compared to the previous period. There has been no significant change in the shares of Kenya's aggregate agricultural imports that originate from African markets. Prior to MTIP, African markets enjoyed sizable shares as destinations of Kenya's exports of cereals, edible oils, and sugar and live animals, and also as sources of imports of cocoa beans, cotton, coffee and tea, sugar, and edible fruits and nuts (Table 10). During MTIP, Kenya considerably increased the shares of its exports of live animals, fish and animal products, roots and tubers, coffee and tea, and spices to African markets to the detriment of non-African markets. Similarly, Kenya increased its intra-African shares of imports of live trees and plants, spices, and oilseeds to the detriment of non-African exporters.

Table 10: Change in intra-African trade share of Kenya's global agricultural trade (%)

	Reference		MTIP	
	Export	Import	Export	Import
Live animals	58.3	17.4	82.1	23.3
Fish & animal products	3.3	42.0	19.7	38.7
Roots & tubers	17.9	0.8	60.1	0.8
Other live trees and plants	1.5	28.0	0.5	84.5
Vegetables	3.1	18.6	4.2	47.1
Edible fruits & nuts	1.4	65.3	2.1	69.7
Coffee & tea	17.6	79.2	22.7	79.4
Spices	33.0	27.6	41.9	40.3
Cereals	96.6	12.1	85.4	10.5
Oilseeds	42.3	44.8	19.0	91.1
Edible oils	95.0	0.7	93.6	3.1
Cane or beet sugar	69.9	75.1	21.1	46.6
Cocoa beans	1.3	91.2	0.1	80.4
Hides & skins	2.7	64.9	5.8	-
Cotton, not carded or combed	7.9	83.0	1.2	-
Cotton, carded or combed	34.9	79.0	-	83.0
Other agricultural products	29.8	27.4	49.2	33.0
Agriculture	16.7	29.0	22.1	29.4

Source: Benin et al. (2016).
Note: Reference period: 1998–2003. Due to data availability, the MTIP years are here restricted to 2010–2013 although the Plan covers the period 2010–2015.

The assessment highlights the progress made by Kenya during MTIP implementation in terms of its participation in African markets for agricultural and food commodities. The next section presents and discusses the simulation scenarios and results. It demonstrates how the evidence generated by the modeling work can contribute to informing and guiding the NAIP planning and design in Kenya to achieve the multiple Malabo goals.

5.3 Assessment of the Kenya Malabo Goals and Milestones

This section presents the assessment of the prospects for agricultural development in Kenya. The assessment uses the analytical framework and the data for Kenya presented in sections 3 and 5.1. The results discussed here build upon the two simulation scenarios for agricultural development introduced in section 4. Thus, the first scenario is the continuity of the historical trends of the economy, including the agricultural sector, referred to as the Business as Usual (BaU) scenario.

The second scenario simulates the successful implementation of the Malabo Agenda on accelerated agricultural growth and transformation and the achievement of the Malabo goals and targets, referred to as the Malabo scenario hereon.

- *Malabo Goals and Milestones for Halving Poverty and Ending Hunger*

The options for Kenya to achieve the Malabo goals on poverty and hunger, i.e. halving poverty between 2015 and 2025, and ending hunger by 2025, are discussed in this section. Moreover, it presents the milestones for income growth and income inequality reduction necessary to achieve the Malabo targets on poverty and hunger.

Halving Poverty Between 2015 and 2025

The overall poverty rate declines by 36 percent between 2015 and 2025 under the current trends of the Kenyan economy as projected in the BaU scenario (Table 11). Thus, the Malabo goal of halving poverty between 2015 and 2025, i.e. reducing by 50 percent the proportion of people under the national poverty line, is not met under the BaU. The decline in both urban and rural poverty headcount indexes, 46 percent and 30 percent, respectively, between 2015 and 2025 fall short of the Malabo target.

Kenya can achieve the Malabo goal on poverty through the successful formulation and implementation of an evidence-based and Malabo compliant NAIP, as simulated under the Malabo scenario. To achieve the Malabo goal on poverty, approximately 5.3 million individuals must be lifted out of poverty between 2015 and 2025, compared to approximately 3.5 million under the BaU (Table 11). Although the decline in the poverty rate between 2015 and 2025 under the Malabo scenario is twice as high in urban areas (74 percent) compared to rural areas (37 percent), the absolute number of persons out of poverty is higher in rural areas (3.2 million) compared to urban areas (2.1 million).

Table 11: Kenya's poverty reduction prospects 2015-2025

	BaU		Malabo	
	Headcount Index (%)	Number of Individuals (Million)	Headcount Index (%)	Number of Individuals (Million)
National	-35.9	-3.5	-50.0	-5.3
Rural	-29.5	-1.9	-36.8	-3.2
Urban	-45.8	-1.6	-73.9	-2.1

Source: Author's compilation from the simulation results (2018).
Note: BaU: Business as usual scenario. Malabo: Successful implementation of the Malabo Agenda.

Ending Hunger by 2025

Under the BaU, the hunger index, or the food poverty headcount index, declines from 32.0 percent in 2015 to 21.4 percent by 2025 (Table 12). Like the poverty reduction prospects, the Malabo goal of ending hunger by 2025, i.e. reducing the percentage of the population below the food poverty line to less than 5 percent, is not met under the BaU. Unlike the poverty reduction prospects, smaller progress is made in meeting the Malabo hunger target under the BaU. To meet the Malabo target, an additional 11.7 million individuals should be lifted out of food poverty by 2025 compared to the BaU. As with poverty, the fight to end hunger should primarily take place in the rural areas. Compared to the BaU, 9 million additional individuals must be lifted out of hunger in rural areas compared to 2.5 million additional individuals in urban areas.

Table 12: Kenya's food poverty prospects by 2025

	BaU		Malabo	
	Headcount Index (%)	Number of Individuals (Million)	Headcount Index (%)	Number of Individuals (Million)
National	21.4	14.0	3.2	2.3
Rural	26.0	11.2	5.0	2.2
Urban	14.9	2.7	0.9	0.2

Source: Author's compilation from the simulation results (2018).
Note: BaU: Business as usual scenario, Malabo: Successful implementation of the Malabo Agenda.

Inclusive Income Growth

The BaU scenario projects past trends (2011-2015) of income growth in Kenya over the 2015–2025 period, yielding 65.5 percent growth in national income over the period, as measured by household final consumption expenditure (Table 13). To achieve the Malabo goals on poverty and hunger, income growth must accelerate to 83.9 percent over the same period. In the Malabo scenario, urban and rural incomes must grow faster by 21 and 16 percentage points, respectively, compared with the BaU.

Table 13: Kenya's income growth prospects by 2025 (%)

	BaU	Malabo
National income	65.5	83.9
Rural income	55.2	71.4
Urban income	84.6	106.0

Source: Author's compilation from the simulation results (2018).
Note: BaU: Business as usual scenario. Malabo: Successful implementation of the Malabo Agenda.

Furthermore, the decline in income inequality, as measured by the Gini index, must be twice as high under the Malabo scenario compared to the BaU (Table 14). The income share of the poorest quintile must increase from 6.6 percent under the BaU scenario to 8.3 percent with the Malabo scenario.

Table 14: Kenya's income inequality reduction 2015-2025 (%)

	BaU	Malabo
Gini Index	-6.5	-12.7
Share of the poorest quintile in national income	6.6	8.3

Source: Author's compilation from the simulation results (2018).
Note: BaU: Business as usual scenario. Malabo: Successful implementation of the Malabo Agenda.

These shared income growth milestones are necessary but not sufficient to achieve the Malabo goal on hunger. Table 15 indicates that income growth enables 6.4 million persons to move out of food poverty, representing 48 percent of the target of 13.3 million persons to be lifted above the food poverty line, in order to eliminate hunger in Kenya by 2025. The contribution of income growth to achieving the goal is 33 and 100 percent in rural and urban areas respectively. Thus, income redistribution trough social assistance in rural areas appears to be a key complementary strategy to the income growth strategy that is expected to end hunger by 2025. Under the Malabo scenario, social protection need to be expanded to 7 million individuals in rural areas by 2025, i.e. 16.1 percent of the rural population.

Table 15: Kenya's number of persons escaping food poverty 2015-2025 (million)

	BaU Scenario	Malabo Scenario	
		Income Growth	Income Growth and Social Assistance
National	1.7	6.4	13.3
Rural	1.3	3.5	10.4
Urban	0.4	2.9	2.9

Source: Author's compilation from the simulation results (2018).
Note: BaU: Business as usual scenario. Malabo: Successful implementation of the Malabo Agenda.

To end hunger by 2025, Kenya must transfer to nearly 7 million rural food poor an amount equivalent to 7.4 percent of the rural food poverty line. The average transfer per individual is equivalent to Kshs 237 per month in constant 2015 prices. Considering the 7 million rural food poor to be assisted, the total expenditures amount nearly Kshs 20 billion in constant 2015 prices, representing nearly 1 percent of the Government total budget in 2015.[13]

Food Consumption Expenditures

Food expenditures increase under the Malabo scenario compared to the BaU (Table 16). The growth rate of food consumption expenditure almost doubles in rural areas, i.e. from 14 percent under the BaU scenario to 25 percent with the Malabo scenario. At the national level, accelerating food consumption expenditure growth to 36 percent over the 2015–2025 period is a key milestone to be reached to achieve the Malabo goals on hunger.

Table 16: Change in Kenya's food and nonfood consumption expenditures 2015–2025, constant 2015 prices (%)

	BaU	Malabo
Nonfood Consumption, total		
National	36.6	54.7
Rural	27.2	44.9
Urban	43.7	62.1
Food Consumption, total		
National	22.5	35.7
Rural	13.6	24.5
Urban	33.0	48.9

Source: Author's compilation from the simulation results (2018).
Note: BaU: Business as usual scenario. Malabo: Successful implementation of the Malabo Agenda.

[13] Kenya's total public expenditure was estimated at KSh 2,028.2 billion in 2015 (AUC, 2018).

Simulations of achieving the Malabo goals of halving poverty between 2015 and 2025 and ending hunger by 2025 have led to the identification of several key milestones related to income growth, income inequality reduction including social protection, and food consumption expenditure increase. The next section discusses the milestones to increase food supply through accelerated growth and transformation of agriculture.

- *Priority Areas for Agricultural Investment and Growth*

Although the agricultural sector contributes 30 percent of the economywide GDP (ECA, AfDB, and AUC, 2017), less than 4 percent of the Government budget is allocated to the sector (Benin et al., 2016). The growth and poverty impact simulation of a marginal increase (by one percent of the total investment budget) in the allocation of public investments to each sector, i.e. agriculture, industry and services, is presented by Table 17. The results indicate that increasing the budget allocation to the agricultural sector is the most effective strategy to accelerate growth and reduce poverty in Kenya. An additional one percent allocation of the public investment budget to agriculture increases the national GDP by 0.8 percent and reduces the poverty headcount index by 1.5 percent. The national GDP grows by around 0.5 percent and the poverty headcount index falls by around 0.8 percent with an additional one percent allocation of public investment to nonagricultural sectors.

Table 17: Kenya's growth and poverty effects of 1% increase in public investments 2015-2025

	GDP Growth	Poverty Headcount Index
Agriculture	0.8	-1.5
Industry	0.4	-0.8
Services	0.5	-0.8

Source: Authors from the simulation results (2018).

For all three sectors, the scenario assumes that the additional investment spending of the Government is financed externally (i.e. borrowing or development assistance). The socioeconomic impact of alternative options to balance the Government investment budget is assessed and presented by Table 18. The efficiency of agricultural public investment is consistent across all the simulated options. Three options for financing the Government investment spending increase are assessed. The first option is “revenue neutral,” i.e. an increase in spending in one sector of the economy, e.g. agriculture, is compensated for by a decrease in spending in other sectors, e.g. non-agriculture. The second is the “budget neutral” option, i.e. Government spending in a specific sector of the economy is compensated for by an equivalent revenue increase through a uniform compensatory tax on households’ gross income. The third option is the “external financing” of the increase of investment, which allows an expansion of the public investment budget financed by external sources (borrowing or development assistance). Table 27 shows that the expansionary budgetary policies through the mobilization of external or internal resources to support the Malabo Agenda yields the most favorable outcomes. Although the revenue neutral option, i.e. increasing public agricultural investment at the expense of public nonagricultural investments, leads to the lowest socioeconomic outcomes among the three options simulated, it is still an improvement compared to the BaU.

Table 18: Kenya’s growth and poverty impact of 1% allocation of public investments, under alternative options for balancing the public investment budget (%)

	Revenue Neutral	Budget Neutral	External Financing
National GDP Growth			
Agriculture	0.3	0.6	0.8
Industry	-0.1	0.2	0.4
Services	0.0	0.3	0.5
Agricultural GDP Growth			
Agriculture	1.4	1.6	1.7
Industry	-0.4	-0.3	-0.2
Services	-0.1	0.0	0.1
Headcount Poverty Index			
Agriculture	-0.5	-1.0	-1.5
Industry	-0.4	-0.3	-0.8
Services	0.3	-0.3	-0.8

Source: Authors from the simulation results (2018).

The growth and income effects of public investment allocation to different agricultural sub-sectors are presented by Table 19. The simulation results indicate that investing in livestock provides higher socioeconomic outcomes in Kenya. Indeed, an additional one percent allocation of public investment spending to livestock generates a 0.9 percent increase in the national GDP, a

2.1 percent increase in agricultural GDP, a 0.4 increase in employment and a 1.4 percent reduction in poverty. An equivalent funding increase allocated to the crops sub-sector generates less agricultural GDP growth, i.e. 1.3 percent, and less employment, i.e. 0.1 percent, but more poverty reduction, i.e. -1.7 percent. Increasing public investment in the fishery sub-sector gives the highest growth outcome but the lowest poverty outcome.

Table 19: Kenya's socioeconomic impact of 1 percent allocation of public investment to agricultural sub-sectors 2015-2025, Annual Variation (%)

	Crops	Livestock	Forestry	Fishery	All Agriculture
National GDP Growth	1.0	0.9	0.6	0.2	0.8
Agricultural GDP Growth	1.3	2.1	2.5	2.6	1.7
Employment	0.1	0.4	0.3	0.0	0.2
Real Income, National	1.1	0.9	0.7	0.5	1.0
Real Income, Rural	0.7	0.4	0.9	0.6	0.6
Poverty Headcount Index, National	-1.7	-1.4	-1.3	-0.9	-1.5
Poverty Headcount Index, Rural	-1.0	-0.6	-1.3	-0.9	-0.9

Source: Authors' computation from the simulation results (2018).

The Malabo Declaration set a goal to promote inclusive growth through the establishment and strengthening of public-private partnerships for at least five priority agricultural commodity value chains with strong linkages to smallholder agriculture. To facilitate the selection of the priority commodities, the analysis identifies and proposes a list of strategic agricultural products. The contribution of the individual agricultural products to domestic consumption increase, economywide growth, job creation, income growth and distribution (thus, poverty reduction), and intra-African trade promotion are used as the selection criteria (Annexed Graphs A.1 to A.4).

In Kenya, the assessment highlights five commodity groups with stronger socioeconomic linkages: coffee and tea, pulses, cattle, fruits and nuts, and vegetables (Table 20). These crops are ranked among the top ten commodities in at less three of the six criteria considered. Coffee and tea and pulses have a strong impact on agricultural intra-African agricultural trade, economic growth, and income generation, particularly in rural areas, and their domestic consumption is likely to increase with income growth (Annexed Graphs A.1 to A.4). Compared to these products, investing in cattle, fruits and nuts, and vegetables creates more job opportunities in the economy, but less income is shared with the rural population and less contribution is made to the intra-African trade of agricultural commodities. Two other crops are identified which have a strong socioeconomic impact to some extent, i.e. *maize* and *poultry*. Maize has a strong impact on economic growth, employment, and income increase, particularly for rural households; however, its effects on domestic consumption growth and intra-African trade are weak. Poultry appears to boost employment and its domestic demand is likely to increase with income growth.

Table 18: Commodity groups with stronger socioeconomic linkages

Commodity Group	Domestic Consumption	Economic Growth	Employment	National Income	Rural Income	Intra-African Trade
Vegetables	X	X	X	X	X	X
Coffee & tea	X		X	X	X	X
Pulses	X		X	X	X	X
Cattle	X	X	X		X	X
Fruits & nuts	X	X	X	X	X	X
Maize		X	X	X	X	
Poultry	X		X			X
Cassava	X	X		X		X

Source: Authors from the simulation results (2018).
Note: Mark "X" indicates the commodity group is ranked among the top ten in the considered criteria.

To achieve the Malabo commitments and goals, an increase in public investment in agricultural production and post-production is crucial. Table 21 presents the results from simulations of increasing public investments along the agricultural value chain. It indicates that a spending increase targeted at raising demand, e.g. a food price subsidy, is likely to provide the highest outcome in terms of economywide growth and income increase (and thus, poverty reduction). An equivalent spending increase targeted at raising supply results in more agricultural GDP growth, but the economywide GDP and income growth effects are lower compared to the demand spending increase.

Table 21: Socioeconomic impact of 1 percent allocation of Kenya's public investment to agricultural production and post-production 2015-2025, annual variation (%)

	Agricultural TFP Increase	Input Subsidy	Increase Investment, Agriculture	Increase Investment, Food Industry	Increase Investment, agricultural and food domestic trading	Reduce Intra-African Trade Cost	Income Transfer to Households	Food Price Subsidy
Economywide GDP Growth	0.6	0.7	0.7	0.3	0.0	0.0	0.1	1.1
Agricultural Growth	1.1	1.4	1.3	-0.2	0.1	0.0	0.0	0.4
Employment	0.1	0.1	0.1	-0.1	0.0	0.0	0.0	0.0
Real Income, National	0.7	0.7	0.7	0.4	0.1	0.1	0.2	1.1
Real Income, Rural	0.5	0.6	0.6	0.5	0.0	0.1	0.2	0.8

Source: Author's computation from the simulation results (2018).

- *Malabo Goals and Milestones for Accelerated Agriculture Growth and Transformation*

This section discusses the agriculture-led growth options available to Kenya to ultimately achieve the Malabo goals on poverty and hunger. The discussion on the Malabo commitments and goals is extended to agricultural growth and productivity, post-production losses, intra-African trade of agricultural commodities, and agricultural investment and financing. We use the Malabo scenario simulations to set sector-wide milestones to contribute to achieving the multiple Malabo commitments and goals simultaneously.

Agricultural Growth

Kenya will achieve the multiple Malabo goals through an agriculture-led growth strategy. Indeed, the growth pattern under the BaU is reversed with the Malabo scenario (Table 22). The annual average agricultural growth rate accelerates from 4.6 percent under the BaU to 7.4 percent under the Malabo scenario. The non-agricultural growth observed under the BaU of 6.3 percent is sustained under the Malabo scenario. To accelerate the agricultural growth rate, interventions across the value chain are necessary. As well as production interventions to increase the supply of agricultural and food products and the purchasing power of consumers, demand interventions are key to providing decent prices and remunerations to producers. We next discuss these potential interventions implemented along the agricultural value chain.

Table 22: Kenya's GDP growth 2015-2025, average annual variation (%)

	BaU	Malabo
National Economy	5.9	6.8
Agriculture	4.6	7.4
Non-agriculture	6.3	6.4

Source: Authors' computation using the simulation results (2018).
Note: BaU: Business as usual scenario. Malabo: Successful implementation of the Malabo Agenda.

Agricultural Productivity and Production

This section investigates the opportunities and key drivers to increase agricultural productivity in Kenya. The results discussed here are drawn from the implementation of the agricultural productivity analysis presented in section 3. The results from the agricultural productivity modeling and analysis indicate that Kenya has opportunities to increase agricultural productivity primarily through the improvement of the technical efficiency of farmers (Table 23). Indeed, considering the existing in-country technologies, agricultural productivity can increase by 40 percent through both technical efficiency improvement and technological progress. Improving technical efficiency solely can increase the productivity by approximately 30 percent. There is little room for technological progress, i.e. there is only a small gap between agroecological zone-specific technology and the best available agricultural technology countrywide. The key drivers of higher technical efficiency among farmers are the use of fertilizers and cooperative membership. That is, farmers that use fertilizer are likely to be more technically efficient than farmers not using fertilizer, while famers belonging to a cooperative are more efficient than non-members. On the other hand, technological progress is also positively related to cooperative membership, the use of fertilizer and technical skills (e.g. education and technical training).

Table 23: Technical efficiency scores in Kenya

	Mean	Median
Meta-Technical Efficiency	0.58	0.60
Technical Efficiency	0.66	0.71
Technological Gap Rate	0.87	0.89

Source: Authors' calculations using the results from a stochastic meta-frontier analysis (2018).

Agricultural productivity, as measured by agricultural value added per hectare of arable land, has increased by approximately 6 percent annually between the periods 2010–2014 and

2003–2007 (Benin et al., 2016). Projected productivity growth over the period 2015–2025, under the BaU scenario, is likely not to be sufficient to achieve the Malabo goal of doubling agricultural productivity between 2015 and 2025. The multiple Malabo goals are achieved with an annual average increase of 8.4 percent in agricultural land productivity over the period 2015–2025, resulting in an overall increase of 124 percent (more than doubling) over the period (Table 24).

Table 24: Kenya's agricultural productivity growth 2015-2025, annual variation (%)

	BaU	Malabo
Agricultural value added per unit value of cultivated area	5.3	8.4
Agricultural value added per unit value of agricultural labor	1.8	5.2
Agricultural input cost, constant value	0.9	-0.6
Agricultural input expenditures per unit of cultivated area	4.7	7.9
Agricultural total factor productivity	2.5	4.8
Agricultural private capital expenditures per unit of cultivated area	3.7	4.0

Source: Authors' computation using the simulation results (2018).
Note: BaU: Business as usual scenario. Malabo: Successful implementation of the Malabo Agenda.

The agricultural productivity analysis discussed earlier indicates that access to inputs, primarily fertilizer use, is the most important driver to improve the technical efficiency of farmers and to increase productivity. Thus, input cost reduction becomes an important milestone to achieve the Malabo productivity goal. The macro analysis projects the real cost of agricultural inputs to decrease by 1.0 percent per year on average. Consequently, input expenditures (in constant prices) per unit of cultivated area are expected to accelerate by 7.9 percent under the Malabo scenario, compared to 4.7 percent under the BaU scenario (Table 24). The reduction of agricultural input cost and the increase in input use in agriculture are complemented by two additional milestones, i.e. an increase in total factor productivity through improved technical efficiency (e.g. through training and other skill development activities) and an increase in agricultural capital expenditure (equipment and machinery, infrastructure, etc.) per unit of cultivated area.

Agricultural production increases by 9.2 percent annually on average between 2015 and 2025 to contribute to achieving the multiple Malabo goals (Table 25). The crops sub-sector will continue to drive agricultural growth over the period 2015–2025, accounting for 63.5 percent of annual agricultural GDP growth (a slight decline as compared to the BaU projection of 66.4

percent). The livestock sector contribution increases from 23.6 to 27.0 percent between the BaU and Malabo scenarios. The contributions of the forestry and fishing sub-sectors remain mostly unchanged between the BaU and Malabo scenarios.

Table 19: Kenya's agricultural production by sub-sector, annual growth (%)

	GDP Growth, Annual		Share GDP	Contribution to Agricultural GDP Growth	
	BaU	Malabo		BaU	Malabo
Agriculture	5.1	9.2	100.0	100.0	100.0
Crops	4.7	8.0	71.9	66.4	63.5
Livestock	5.9	12.0	20.4	23.6	27.0
Forestry	6.5	10.9	5.2	6.6	6.2
Fishing	6.6	11.7	2.6	3.4	3.3

Source: Authors' computation using the simulation results (2018).
Note: BaU: Business as usual scenario. Malabo: Successful implementation of the Malabo Agenda.

Agricultural Post-Production Productivity and Production

Investment and productivity in agricultural post-production industries, i.e. food possessing industries and agricultural and food wholesale and retail industries, increase under the Malabo scenario compared to the BaU (Table 26). Agricultural post production total factor productivity increases in aggregate by 4 percent per year on average. This implies a 50 percent increase over the period 2015–2025. To meet the target, the productivity of the food and beverage industry is expected to increase more than that of agricultural and food wholesale and retail trade services. The primarily driver of the productivity increase is the increase in public and private investment, as indicated by the growth in capital expenditure per unit of agricultural output presented in Table 26.

Table 20: Kenya's increase in capital expenditures and TFP in agricultural post-production industries 2015-2025, average annual variation (%)

	BaU	Malabo
Capital expenditure per unit of agricultural output, agricultural and food domestic trade	1.3	4.2
Capital expenditure per unit of agricultural output, agricultural transformation	1.4	4.0
Total factor productivity, agricultural and food wholesale and retailed trade services, annual change	0.6	3.4
Total factor productivity, food and beverage industry, annual change	0.7	4.7

Source: Authors' computation using the simulation results (2018).
Note: TFP: Total Factor Productivity. BaU: Business as usual scenario. Malabo: Successful implementation of the Malabo Agenda.

Intra-Africa Trade in Agricultural Goods and Services

Under the BaU, intra-African trade, i.e. exports and imports of agricultural and food products and services grow at an annual rate of 2.8 percent. This performance is below the average annual growth rate of 12.4 percent required to achieve the Malabo intra-African trade goal (Table 27). The simulation assumes a decline in the cost of intra-African trade of 10 percent per year on average to boost exports and imports among African countries. Thus, the ratio of agricultural and food intra-African exports-to-imports is expected to increase under the Malabo scenario compared to the BaU. Moreover, the share of processed food in total agricultural and food exports increases and implies more sophistication in traded agricultural goods. The imports and exports ratio to GDP, which measures agriculture and food trade openness, changes slightly under the Malabo scenario compared to the BaU.

Table 21: Kenya's intra-Africa trade of agricultural commodities 2015-2025 (%)

	BaU	Malabo
Intra-Africa exports and imports of agricultural and food products, annual growth	2.8	12.4
Import and export of agriculture and food commodities, ratio-to-GDP	27.9	29.3
Agricultural and food exports to imports ratio	296.5	355.2
Processed food, share total agricultural and food exports	18.7	31.6
Intra-Africa agricultural and food trade cost, annual variation	0.0	-9.8

Source: Authors' computation using the simulation results (2018).
Note: TFP: Total Factor Productivity. BaU: Business as usual scenario. Malabo: Successful implementation of the Malabo Agenda.

Consumption of Locally Produced Food

The food import dependency ratio is used to measure the level of consumption of locally produced food items. The decline in the food import dependency ratio between the BaU and Malabo scenarios implies an increase in consumption of locally produced food (Table 28). This result is driven by declines in the prices of locally produced food compared to imported food.

Table 22: Kenya's consumption of locally produced food 2015-2025 (%)

	BaU	Malabo
Food Import Dependency Ratio	5.6	5.1
CPI Food Products, Annual Change	-1.1	-4.6
CPI Locally Produced Food, Annual Change	-1.4	-4.7
CPI Imported Food, Annual Change	1.7	-0.2

Source: Authors' computation using the simulation results (2018).
Note: CPI: Consumption Price Index. BaU: Business as usual scenario. Malabo: Successful implementation of the Malabo Agenda.

- *Malabo Goals and Milestones for Agricultural Investments and Financing*

Kenya will achieve the Malabo commitments and goals by increasing public and private investment spending in the agricultural sector. The agricultural share in total Government investment expenditure must increase from less than 4 percent under the BaU to 10 percent with the implementation of the Malabo Agenda (Table 29). Government investment expenditures are financed from external sources (i.e. borrowing and foreign aid) to minimize the crowding out of private investments. Alternative sources of financing the agricultural investment increase are discussed later in this section. Indeed, the increase in Government agricultural expenditure is likely to adversely impact non-agricultural growth because of the Government's budget constraint. On the other hand, domestic financing of the Government spending increase is likely to crowd out private investment and reduce economywide growth.

Table 23: Kenya's public agricultural expenditure 2015-2025 (%)

	BaU	Malabo
Public investment expenditures, total annual growth	14.6	18.9
Public investment expenditures, share external financing	3.6	25.5
Public investment expenditures, share agriculture	3.5	10.0

Source: Authors computation from the simulation results (2018).
Note: BaU: Business as usual scenario. Malabo: Successful implementation of the Malabo Agenda.

The financing of the Malabo Agenda requires a mix of public and private investments. The implementation of the Malabo Agenda contributes to improving the competitiveness of the agriculture sector. As a result, private investments increase under the Malabo scenario (2.0 percent annually) compared to a decreasing trend (-10.3 percent) under the BaU (Table 30). Although foreign investments continue to account for nearly two-thirds of total private investments, a slight improvement in the share of domestic investment is noticed under the Malabo scenario.

Table 30: Kenya's private investment in agriculture 2015-2025, average annual growth (%)

	BaU	Malabo
Private investment economywide, annual growth	4.9	5.9
Private investment economywide, share foreign investment	66.3	63.9
Private investment in agriculture, annual growth	-10.3	2.0

Source: Authors' computation from the simulation results (2018).
Note: BaU: Business as usual scenario. Malabo: Successful implementation of the Malabo Agenda.

- *Malabo Goals and Milestones for Inclusive Growth and Value Chain Development*

A set of agricultural commodities with strong socioeconomic linkages are identified and discussed in the previous section. For each individual commodity, the analysis turns into setting the milestones related to agricultural production and productivity growth, input and investment needs, and the contribution to intra- and extra-Africa trade. Indeed, the results indicate that the Malabo targets are met with substantial increases in the output of the strategic agricultural products compared to the BaU (Table 31). The commodities' average annual output growth rates are four times higher with the Malabo scenario compared to the BaU, ranging respectively between 9–15 percent against 2–4 percent. The output growth is primarily driven by productivity increases for the strategic agricultural products in the Malabo scenario compared to the BaU, ranging respectively from 6–17 percent against less than 2 percent.

Table 24: Production and productivity for strategic agricultural commodities in Kenya 2015-2025, average annual variation (%)

Agricultural Product	Production		Productivity*	
	BaU	Malabo	BaU	Malabo
Maize	2.4	10.1	-0.3	10.5
Pulses	2.2	8.6	1.0	5.6
Vegetables	2.2	9.3	-0.7	6.4
Fruits	1.8	8.9	-0.4	5.7
Coffee and Tea	2.4	9.0	1.9	6.9
Cattle	3.6	14.6	1.3	16.7
Poultry	3.5	14.0	0.9	16.1

Source: Authors' computation from the simulation results (2018).
Note: *Total factor productivity. BaU: Business as Usual scenario. Malabo: Malabo scenario

The productivity growth is driven by an increasing use of inputs by the strategic agricultural products, between 9 and 10 percent per year on average under the Malabo scenario (Table 32). The average annual change in the ratio of input use to labor use by the strategic agricultural products ranges between -2 and 3 percent in the BaU scenario. Capital intensity, measured by the constant value of capital per unit value of labor, increases for maize, cattle and poultry. Thus, workers in these activities need to be equipped with more capital to contribute to increasing production and productivity.

Table 25: Capital and input use of strategic agricultural commodities in Kenya 2015-2025, average annual variation (%)

Agricultural Product	Capital Intensity		Input Use Intensity	
	BaU	Malabo	BaU	Malabo
Maize	4.2	8.0	3.0	9.5
Pulses	5.3	4.7	2.5	8.5
Vegetables	4.0	5.1	2.9	8.9
Fruits	4.3	4.5	2.3	8.6
Coffee and Tea	5.7	4.8	2.4	8.5
Cattle	5.5	9.0	-1.5	10.0
Poultry	5.4	9.4	-1.9	9.7

Source: Authors' computation from the simulation results (2018).
Note: Capital Intensity: Capital-to-labor ratio. Input Use Intensity: Input-to-labor ratio; BaU: Business as Usual scenario. Malabo: Malabo scenario

Coffee, tea, and pulses are important for the country's intra- and extra-African exports. Under the Malabo scenario both intra- and extra-African trade is expected to increase compared to the BaU (Table 33). The intra-African trade of coffee and tea and pulses increases respectively by 13 and 10 percent under the Malabo scenario compared to 8 and 3 percent for extra-African trade. Consequently, the shares of African exports in the total export of coffee and tea and pulses increase respectively by 3 and 4 percent per year on average.

Table 26: Kenya's change in intra and extra Africa exports for strategic agricultural commodities 2015-2025, average annual variation (%)

Agricultural Product	Intra-Africa Exports Growth			Extra-Africa Exports Growth			Intra-Africa Share in Total Exports		
	Initial Ratio to Output	Average Annual Change		*Initial Ratio to Output*	Average Annual Change		*Initial Share*	Average Annual Change	
		BaU	Malabo		BaU	Malabo		BaU	Malabo
Maize	*0.1*	-4.4	29.0	*0.0*	-6.3	29.6	*85.4*	0.3	-0.1
Pulses	*10.8*	-0.6	9.6	*11.2*	-0.9	2.6	*49.2*	0.1	3.1
Vegetables	*0.0*	-6.7	12.4	*0.9*	-9.4	6.4	*4.2*	2.9	5.3
Fruits	*0.1*	-7.0	8.7	*3.4*	-9.8	1.4	*2.1*	3.1	7.0
Coffee and Tea	*22.0*	1.8	13.3	*77.1*	2.5	7.6	*22.2*	-0.6	3.9
Cattle	*0.3*	4.2	44.8	*0.1*	6.1	52.8	*82.1*	-0.3	-1.1
Poultry	*0.7*	2.5	47.1	*0.1*	3.6	56.4	*82.1*	-0.2	-1.2

Source: Randriamamonjy and Thurlow (2016), Benin et al. (2016), and authors computation from the simulation results (2018).

Note: Capital Intensity: Capital-to-labor ratio. Input Use Intensity: Input-to-land ratio for crops and input-to-capital ratio for livestock. BaU: Business as usual scenario; Malabo: Malabo scenario

6. CONCLUSION

The 2014 Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods has brought challenges by expanding the number of commitments and goals under the CAADP framework. The Declaration upheld commitments to the key CAADP targets of 6 percent annual agricultural growth and a 10 percent public agricultural expenditure share, while also laying out ambitious new goals to be achieved by 2025, including, among others, the goals on halving poverty, ending hunger, doubling agricultural productivity, halving post-production losses, and tripling intra-African agricultural trade. As part of ongoing provision of technical support to knowledge and evidence needs related to CAADP, IFPRI and ReSAKSS have developed an economic modeling framework related to the Malabo Agenda.

The framework consists of a three-layer simulation model that aims at capturing multiple Malabo commitments and goals. First, the agricultural productivity analysis uses the stochastic meta-frontier technique to assess opportunities to increase agricultural productivity. Second, the economywide analysis uses an agricultural and investment focused computable general equilibrium model to capture the Malabo goals on agricultural growth, intra-African trade of agricultural commodities, and public and private agricultural investments. Third, the microeconomic analysis builds upon statistical economic modeling to allow direct measurement and simulation of the Malabo goals on poverty and hunger.

The modeling framework is applied to Kenya using the country's most recent available data. Thus, the agricultural household survey for 2010 is used for the agricultural productivity analysis. The computable general equilibrium model is calibrated with the 2013 Social Accounting Matrix. Finally, the microeconomic analysis is implemented using the 2015/16 Kenya Integrated Household Budget Survey.

The simulation results indicate that the Malabo goal of halving poverty between 2015 and 2025 can be achieved with accelerated income growth and income inequality reduction in

Kenya. A rural-focused income growth strategy is more likely to contribute to achieving the poverty reduction goal. However, the income growth strategy is not sufficient to achieve the goal of ending hunger by 2025. It must be complemented by a social assistance strategy to lift about 16 percent of the rural population out of hunger. The Malabo goals on poverty and hunger can be achieved through key milestones related to income growth, income inequality reduction including social protection, and food consumption expenditure increase, as presented in Annex B.

Agriculture-led income growth is identified as the most efficient option to achieve the Malabo commitments and goals on poverty and hunger in Kenya. Therefore, the country must accelerate the agricultural GDP growth rate to between 7 and 8 percent per year on average to close the income growth and income inequality gaps. Sustaining the current nonagricultural GDP growth rate of between 6 and 7 percent is also an important building block to achieving the Malabo goals on poverty and hunger.

Both supply and demand side strategies are important to achieving the Malabo growth goals, with investments in increasing agricultural productivity (on the supply side) and food price subsidies (on the demand side) appearing to be the most efficient options to accelerate agricultural growth. Closing the technical efficiency gaps among farmers remains a key challenge to increasing agricultural productivity in Kenya. Although the crops sub-sector remains the biggest contributor to agricultural GDP growth (accounting for two-thirds of growth), livestock appears to be the most efficient sector to invest in. Annex B presents key milestones to achieve the Malabo goals on accelerated growth and transformation of agriculture. The milestones are related to agricultural productivity and production growth, agricultural post-production productivity and production growth, intra-African trade of agricultural commodities, and the consumption of locally produced food items.

Public agricultural investment must be increased to 10 percent of the Government's total investment budget to meet the multiple Malabo commitments and goals. Three options of financing the agricultural expenditure increase are tested, i.e. the revenue neutral option, the budget neutral option, and external financing of the increase of investment expenditures. The latter option produces the highest growth and poverty outcomes compared to the other options. The budget neutral option implies that an expenditure increase in one sector is compensated for by an expenditure decrease in other sectors. This option is less efficient than the expansionary budgetary policies through the mobilization of external or internal resources to support the Malabo Agenda, but its outcomes are still better compared to the business as usual scenario, i.e. the continuity of the current performance of the economy. Private agricultural investment increases under the implementation of the Malabo Agenda compared to the declining trend under the business as usual scenario. The investment increase is triggered by a more competitive agricultural sector compared to the nonagricultural sectors.

The modeling of the Malabo Agenda of accelerated agricultural growth and transformation in Kenya has contributed to setting coherent Malabo goals and milestones for the country as discussed in section 5 and presented in Annex B. These key agricultural sectorwide milestones and targets will facilitate the design of a second generation National Agricultural Investment Plan for Kenya that is evidence-based and compliant with the Malabo Agenda.

When data and time permit, the modeling framework can be extended on two fronts in future applications, i.e. improving the model design and including further Malabo thematic goals.

Regarding the model design, the macro and micro models are linked through per capita real income disaggregated by residential area, i.e. urban and rural, and by household final consumption expenditure quintile in each residential area. Thus, factors' disaggregated per capita real revenues can serve as linking variables along with per capita real income to establish more coherence between the macro and micro models.

Furthermore, a top-down mechanism is applied in the interaction between the macro and micro models. However, the interaction can be designed to include the feedback effect from the micro to the macro model, and vice versa, though an integrated mechanism.

Aggregate public agricultural investment is related to agricultural productivity, as is the aggregate public expenditure on input use in agriculture. When data permit, the investment-led productivity growth can be applied to individual production factors (i.e. labor, land, herds, machineries and equipment, other capital) and individual input use (i.e. seeds, fertilizers, other inputs). However, this specification requires further data to disaggregate public investment across various production factors and input uses. Assigning output growth elasticities to each public spending category is a related challenge.

Regarding the inclusion of more Malabo thematic issues, the modeling framework is designed to assess the overarching goals on poverty, growth and investments. However, the framework also includes and traces commodity specific value chains through the supply (upstream) and demand (downstream) segments, and to some extent the food processing (midstream) segment. When data permit, the food processing industry and wholesale and retail trade services can be further disaggregated and traced.

The Malabo goals on intra-Africa trade of agricultural commodities are covered by the modeling framework through the separation between intra- and extra-African trade. Finite export demand elasticity parameters, i.e. endogenous Free on Board (F.O.B.) prices, are used for intra-African trade, while infinite elasticity parameters, i.e. exogenous F.O.B. prices, are applied to extra-African trade. Finite import elasticity parameters, i.e. endogenous Cost, Insurance and Freight (C.I.F.) prices, should also be defined between the country and the rest of Africa. Furthermore, exogenous intra-African export demand and import supply are to be informed by empirical evidence on regional trade to better capture the opportunities for intra-African trade of agricultural commodities.

The framework can be extended to include other Malabo thematic issues such as nutrition and food security and gender. Nutrition metrics are captured at the household and individual levels, and if data permit, they can be included in the modeling framework following the approach used to assess the overall and food poverty measures.

Poverty rates among women can be captured using the micro data and the microsimulation results through the sex disaggregation of individuals within poor households and/or using the criteria of poverty among heads of households. Moreover, women's employment levels and labor income across the agricultural value chain, as well as female and male household-head income, can be captured by the macro model to inform the Malabo goal of women's economic participation in agriculture. Furthermore, the capital endowment of men and women (such as land) and access to inputs are other dimensions that can be captured by the modeling framework when data permit.

Finally, bridges can be built between the proposed modeling framework and other Malabo thematic area-specific modeling frameworks, such as those used to assess climate smart agriculture and resilience.

REFERENCES

AU (African Union). 2014. "The Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods." Addis Ababa, Ethiopia.

African Union Commission (AUC). 2018. "Inaugural Biennial Review Report of the African Union Commission on the Implementation of the Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods." Addis Ababa, Ethiopia. http://www.resakss.org/sites/default/files/BR English Draft Print.pdf.

Battese GE, Rao DS. 2002. "Technology Gap, Efficiency, and a Stochastic Meta-frontier Function." *International Journal of Business and Economics* 1 (2): 87–93.

Beegle, Kathleen, Luc Christiaensen, Andrew Dabalen, and Isis Gaddis. 2016. *Poverty in a Rising Africa*. The World Bank. https://doi.org/10.1596/978-1-4648-0723-7.

Benin, Sam, N. Covic, A. S. EL Vilaly, Ismaël Fofana, J. Koo, N. Minot, S. Odjo, F Traore, and F. Wouterse. 2016. "Kenya Agricultural Development Status Assessment." Washington, DC.: International Food Policy Research Institute (IFPRI). http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/131060.

Benin, Sam, Alejandro Nin-Pratt, Shenggen Fan, Clemens Breisinger, Tewodaj Mogues, James Thurlow, and Xinshen Diao. 2008. "Growth and Poverty Reduction Impacts of Public Investments in Agriculture and Rural Areas." *ReSAKSS Working Paper*, no. 7. http://pdf.usaid.gov/pdf_docs/pnads610.pdf.

Blanchflower, David, and Andrew Oswald. 1989. "The Wage Curve." NBER Working Paper No. 3181 Cambridge, MA. https://doi.org/10.3386/w3181.

Bourguignon, Francois. 2003. "The Growth Elasticity of Poverty Reduction: Explaining Heterogeneity across Countries and Time Periods." Washington, DC: World Bank. http://documents.worldbank.org/curated/en/503161468780002293/The-growth-elasticity-of-poverty-reduction-explaining-heterogeneity-across-countries-and-time-periods.

Bourguignon, François, and Amedeo Spadaro. 2006. "Microsimulation as a Tool for Evaluating Redistribution Policies." *Journal of Economic Inequality* 4 (1): 77–106. https://doi.org/10.1007/s10888-005-9012-6.

Bourguignon F., A.-S. Robilliard and S. Robinson (2005) 'Representative versus real households in the macro-economic modeling of inequality', in T. Kehoe, T.N. Srinivasan, J. Whalley (eds.), Frontiers in Applied General Equilibrium Modeling: Essays in Honor of Herbert Scarf, Cambridge University Press, Cambridge, p. 219-254.

Breisinger, Clemens, Xinshen Diao, and James Thurlow. 2009. "Modeling Growth Options and Structural Change to Reach Middle Income Country Status: The Case of Ghana." *Economic Modelling* 26 (2): 514–25. https://doi.org/10.1016/j.econmod.2008.10.007.

Cockburn, John, Luc Savard, and Luca Tiberti. 2014. "Macro-Micro Models." In *Handbook of Microsimulation Modelling*, edited by Cathal O'Donoghue, 251–74. Contributions to Economic Analysis. Emerald Group Publishing Limited. https://doi.org/10.1108/S0573-85552014293.

Coelli, T.J., D.S. Prasada Rao and G.E. Battese. 1998. *An Introduction to Efficiency and Productivity Analysis*. Boston: Kluwer Academic.

Decaluwé, B., A. Lemelin, V. Robichaud, and H. Maisonnave. 2013. "PEP 1-t Standard PEP Model, Single Country, Dynamic Version."

Debowicz, D. 2016. Does the microsimulation approach used in macro–micro modelling matter? An application to the distributional effects of capital outflows during Argentina's Currency Board regime. Economic Modelling, Volume: 54, Pages: 591 - 599.

Devarajan, S. & Go, D.S. (2001). A macroeconomic framework for poverty reducing strategy papers (with an application to Zambia), mimeo, Washington, D.C., The World Bank.

Diao, Xinshen, ed.; Thurlow, James, ed.; Benin, Samuel, ed. and Fan, Shenggen, Ed. 2012. "Strategies and Priorities for African Agriculture : Economywide Perspectives from Country Studies." Washington, D.C.: International Food Policy Research Institute (IFPRI). https://doi.org/10.2499/9780896291959.

Diao, X., Hazell, P., Resnick, D. and Thurlow, J. 2007. "The Role of Agriculture in Development: Implications for Sub-Saharan Africa." Research Report 153. Washington, DC: International Food Policy Research Institute (IFPRI).

Diao, Xinshen, and Alejandro Nin Pratt. 2007. "Growth Options and Poverty Reduction in Ethiopia – An Economy-Wide Model Analysis." *Food Policy* 32 (2): 205–28. https://doi.org/10.1016/j.foodpol.2006.05.005.

ECA, AfDB, and AUC. 2017. *African Statistical Yearbook*. Addis Ababa, Ethiopia: ECA.

FAO, IFAD, UNICEF, WFP, and WHO. 2017. *The State of Food Security and Nutrition in the World 2017. Building resilience for peace and food security*. Rome, FAO. www.fao.org/publications%0Ahttp://www.fao.org/state-of-food-security-nutrition/en.

FAO (Food and Agriculture Organization). "FAOSTAT [Data File]. Accessed November 2017. http://www.fao.org/faostat/en/#data.

Ferreira, J. & Horridge, M. (2006). The Doha Round, Poverty and Regional Inequality in Brazil, Chapter 7 in Thomas W. Hertel and L. Alan Winters (eds), Putting Development Back into the Doha Agenda: Poverty Impacts of a WTO Agreement, Palgrave Macmillan and the World Bank, Washington, D.C.

Fofana, Ismaël; Badiane, Ousmane; Camara, Alhassane; and Goundan, Anatole. 2018. "Groundnut Export Tax in Senegal: Winners and Losers." IFPRI Discussion Paper 1757. Washington, DC.: International Food Policy Research Institute (IFPRI). http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/132809.

Fofana, Ismaël, Margaret Chitiga-Mabugu, and Ramos Mabugu. 2018. "South Africa Milestones to Achieving the Sustainable Development Goals on Poverty and Hunger." IFPRI Discussion Paper 1731. Washington, DC.: International Food Policy Research Institute (IFPRI). http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/132710.

Fofana, Ismaël, Mamadou Yaya Diallo, Ousseynou Sarr, and Abdou Diouf. 2015. "2011 Social Accounting Matrix for Senegal." IFPRI Discussion Paper 1417. Washington, DC.: International Food Policy Research Institute (IFPRI). http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/128960.

Foster, James, Joel Greer, and Erik Thorbecke. 1984. "A Class of Decomposable Poverty Measures." *Econometrica* 52 (3): 761. https://doi.org/10.2307/1913475.

Herault, N. 2010. Sequential linking of computable general equilibrium and microsimulation models: acomparaison of behavioural and reweighting techniques. *International Journal of Microsimulation* 3(1), 35-42.

Johnson, Michael, Regina Birner, Jordan Chamberlin, Xinshen Diao, Shenggen Fan, Alejandro Nin-Pratt, Danielle Resnick, Liang You, and Bingxin Yu. 2008. "Regional Strategic Alternatives for Agriculture-Led Growth and Poverty Reduction in West Africa." ReSAKSS Working Paper No. 22. International Food Policy Research Institute (IFPRI).

Johnson, Michael E., Hiroyuki Takeshima, and Kwabena Gyimah-Brempong. 2013. "Assessing the Potential and Policy Alternatives for Achieving Rice Competitiveness and Growth in Nigeria." 1301. IFPRI Discussion Paper. Washington, DC: International Food Policy Research Institute (IFPRI).

Jung, Hong-Sang and Thorbecke, Erik. 2001. "The Impact of Public Education Expenditure on Human Capital, Growth, and Poverty in Tanzania and Zambia : A General Equilibrium Approach." Working Paper No. 01/106. Washington DC.: IMF https://www.imf.org/en/Publications/WP/Issues/2016/12/30/The-Impact-of-Public-Education-Expenditure-on-Human-Capital-Growth-and-Poverty-in-Tanzania-15267.

KNBS (Kenya National Bureau of Statistics). 2018. *Basic Report on Well-Being in Kenya: Based on the 2015/16 Kenya Integrated Household Budget Survey (KIHBS)*. Nairobi.

———. 2015. "2015/16 Kenya Integrated Household Budget Survey." Nairobi.

Lofgren, Hans, Marcelle Thomas, and Moataz El-said. 2002. *A Standard Computable General Equilibrium (CGE) Model in GAMS*. Washington, D.C.: International Food Policy Research Institute (IFPRI).

Meagher, G. A. 1993. "Forecasting Changes in Income Distribution: An Applied General Equilibrium Approach." Preliminary Working Paper No. OP-78. Melbourne, Australia: Centre of Policy Studies and The Impact Project, Monash University.

Melo-Becerra, Ligia Alba, and Antonio José Orozco-Gallo. 2017. "Technical Efficiency for Colombian Small Crop and Livestock Farmers: A Stochastic Meta-frontier Approach for Different Production Systems." *Journal of Productivity Analysis* 47 (1). https://doi.org/10.1007/s11123-016-0487-x.

Mogues T., Fan S., and Benin S. 2015. Public Investment in and for Agriculture. *The European Journal of Development Research*, Palgrave Macmillan;European Association of Development Research and Training Institutes (EADI), vol. 27(3), pages 337-352, July.

NEPAD, New Partnership for African Development. 2015. "The CAADP Results Framework (2015-2025)." http://www.nepad.org/resource/caadp-results-framework-2015-2025.

Randriamamonjy, Josee; Thurlow, James. 2017. "Social Accounting Matrix for Kenya: A Nexus Project SAM." Washington, DC.: International Food Policy Research Institute (IFPRI). http://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/131504/filename/131713.pdf.

Statistics South Africa. 2017. "Poverty Trends in South Africa: An Examination of Absolute Poverty between 2006 and 2015." Pretoria: Statistic South Africa.

Lee, T. C., and C. G. Judge. 1996. "Entropy and Cross Entropy Procedure for Estimating Transition Probabilities from Aggregate Data." In *Bayesian Analyisis in Statistics and Econometrics*, edited by D.A. Berry, K.A. Chaloner, and J. K. Geweke. New York: Wiley.

Thurlow, James, Jane Kiringai, and Madhur Gautam. 2007. "Rural Investment to Accelerate Growth and Poverty Reduction in Kenya." IFPRI Discussion Papers. 723. Washington, D.C.: International Food Policy Research Institute (IFPRI). http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/40627.

United Nations. 2017. "World Population Prospects: The 2017 Revison [Database]." https://population.un.org/wpp/.

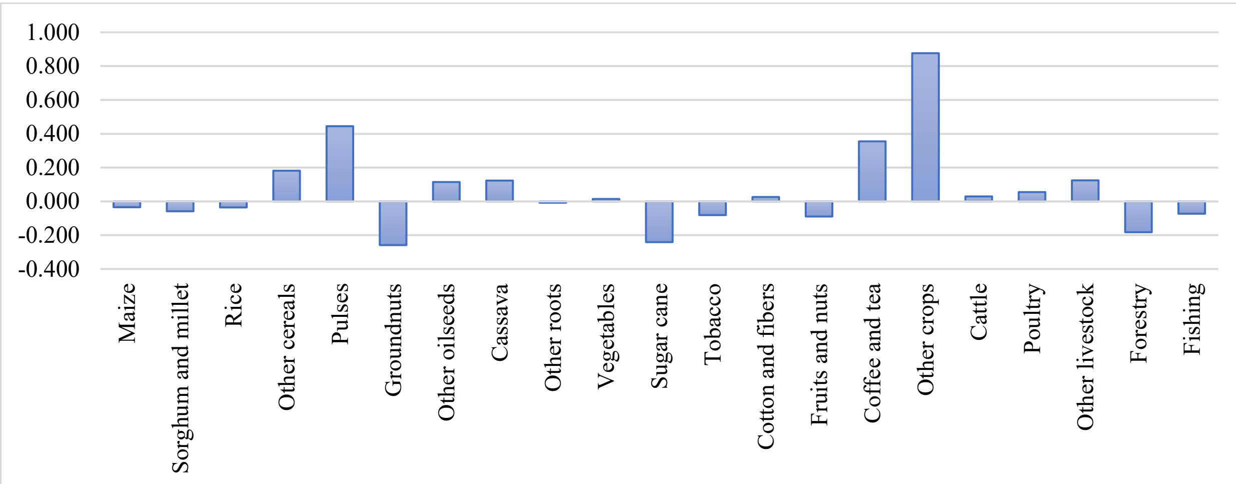
Vos, R. and Sanchez, M. 2010. A Non-Parametric Microsimulation Appraoch to Assess Changes in Inequality and Poverty. International Journal of Microsimulation. 3(1), 8-23.

World Bank. 2017. "World Development Indicators [Data File]. Accessed November 2017

———. 2007. *World Development Report 2008*. World Bank. https://doi.org/10.1596/978-0-8213-6807-7.

ANNEX A: ADDITIONAL SIMULATION RESULTS

Figure A.1: Effect on intra-Africa agricultural exports and imports volumes of a marginal increase in public investment by agricultural commodity, percent changes compared to the baseline

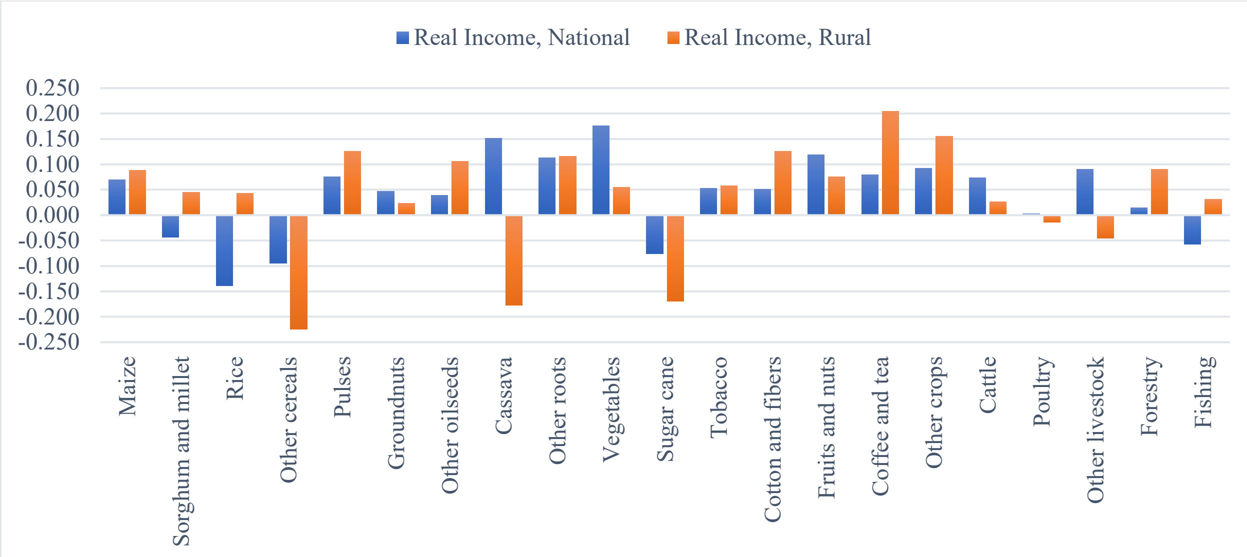


Source: Authors computation from the simulation results (2018).
Note: An increase of 0.1 percent of total public investment expenditure is implemented for every agricultural commodity.

Figure A.2: Effect on GDP and employment of a marginal increase in public investment by agricultural commodity, percent changes compared to the baseline

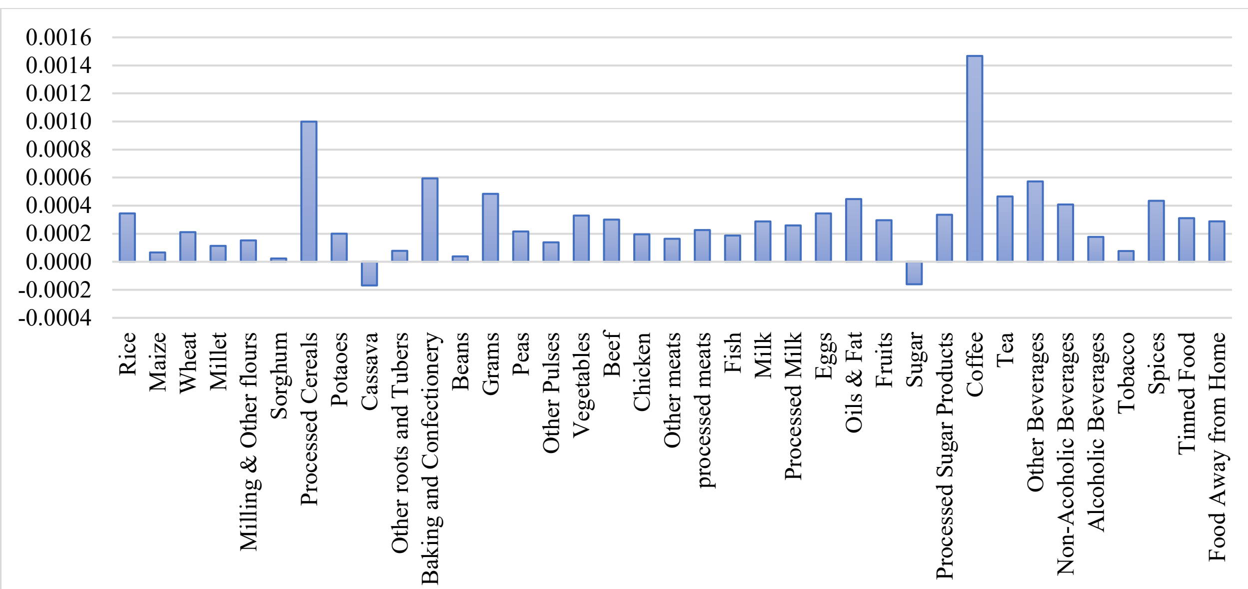
Source: Authors computation from the simulation results (2018).
Note: An increase of 0.1 percent of total public investment expenditure is implemented for every agricultural commodity.

Figure A.3: Effect on the real incomes of a marginal increase in public investment by agricultural commodity, percent changes compared to the baseline



Source: Authors computation from the simulation results (2018).
Note: An increase of 0.1 percent of total public investment expenditure is implemented for every agricultural commodity.

Figure A.5: Food supply cost by agricultural commodity with a marginal increase in real income, percent changes compared to the baseline



Source: Authors computation from the simulation results (2018).
Note: The graph reports the values of the Lagrangian parameters under an increase by 1 percent of aggregate real (mean) income with constrained supply of food products.

ANNEX B: MALABO COMPLIANT RESULTS FRAMEWORK FOR KENYA

Goal	Result	Metric	Target									
			2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Reduce poverty and end hunger	Reduce poverty	National poverty headcount index, national threshold	0.343	0.325	0.307	0.289	0.271	0.253	0.235	0.217	0.199	0.181
		Rural poverty headcount index, national threshold	0.386	0.371	0.357	0.342	0.327	0.312	0.298	0.283	0.268	0.253
		National poverty headcount index, international threshold	0.150	0.140	0.129	0.118	0.108	0.097	0.087	0.076	0.065	0.055
		Rural poverty headcount index, international threshold	0.208	0.195	0.182	0.169	0.156	0.143	0.130	0.117	0.104	0.091
	End hunger	National food poverty index	0.292	0.264	0.235	0.207	0.179	0.150	0.122	0.094	0.065	0.037
		Rural food poverty index	0.327	0.296	0.265	0.235	0.204	0.173	0.142	0.112	0.081	0.050
		National extreme poverty index	0.078	0.069	0.061	0.053	0.044	0.036	0.028	0.020	0.011	0.003
		Rural extreme poverty index	0.101	0.091	0.080	0.069	0.058	0.047	0.037	0.026	0.015	0.004
	Income growth	Household final consumption expenditure national, growth rate	0.063	0.130	0.200	0.276	0.356	0.441	0.532	0.628	0.730	0.839
		Household final consumption expenditure rural, growth rate	0.055	0.114	0.176	0.241	0.309	0.382	0.458	0.539	0.624	0.714
		Food consumption expenditure national, growth rate	0.058	0.120	0.185	0.254	0.328	0.405	0.487	0.574	0.665	0.762
		Food consumption expenditure rural, growth rate	0.052	0.106	0.163	0.223	0.286	0.352	0.422	0.495	0.572	0.654
		GDP, annual growth rate	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068
		Number of job created per annum, growth rate	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043	0.043
	Income Inequality reduction	Gini index	0.395	0.381	0.377	0.372	0.368	0.363	0.359	0.354	0.350	0.345
		Share of the poorest quintile in national income	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
		Share of the poorest quintile in food expenditure	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052

ANNEX B: MALABO COMPLIANT RESULTS FRAMEWORK FOR KENYA (CONT.)

Goal	Result	Metric	Target									
			2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Accelerate agricultural growth & transformation	Increase agricultural productivity	Total factor productivity, growth rate	0.048	0.098	0.151	0.206	0.264	0.325	0.388	0.455	0.525	0.598
		Agricultural value added per unit of cultivated land, growth rate	0.084	0.175	0.274	0.381	0.497	0.622	0.759	0.906	1.067	1.240
		Agricultural value added per unit of agricultural labor, growth rate	0.052	0.107	0.164	0.225	0.288	0.355	0.426	0.500	0.578	0.660
		Input spending, in constant 2015 price, per unit of cultivated land, growth rate	0.079	0.164	0.256	0.355	0.463	0.578	0.703	0.837	0.982	1.139
		Agricultural input cost, constant 2015 price, growth rate	-0.006	-0.012	-0.018	-0.024	-0.030	-0.035	-0.041	-0.047	-0.053	-0.058
	Accelerate agricultural output growth	Agricultural production index	0.092	0.192	0.302	0.422	0.553	0.696	0.852	1.022	1.208	1.411
		Crops production index	0.080	0.166	0.260	0.360	0.469	0.587	0.714	0.851	0.999	1.159
		Livestock production index	0.120	0.254	0.405	0.574	0.762	0.974	1.211	1.476	1.773	2.106
		Forestry production index	0.109	0.230	0.364	0.513	0.677	0.860	1.063	1.288	1.537	1.814
		Fishery production index	0.117	0.248	0.394	0.557	0.739	0.942	1.170	1.423	1.707	2.024
		Agricultural capital spending, in constant 2015 price, per unit of cultivated land	0.040	0.082	0.125	0.170	0.217	0.265	0.316	0.369	0.423	0.480
		Agricultural land use	0.009	0.018	0.027	0.036	0.046	0.055	0.065	0.074	0.084	0.094
	Reduction agricultural post-production losses	Total factor productivity, wholesale and retailed trade agricultural and food products	0.042	0.086	0.131	0.179	0.228	0.280	0.334	0.390	0.448	0.509
		Total factor productivity, agricultural transformation industry	0.040	0.082	0.125	0.170	0.217	0.265	0.316	0.369	0.423	0.480
		Capital spending-to-agricultural output ratio, wholesale and retailed trade agricultural and food products	0.042	0.086	0.131	0.179	0.228	0.280	0.334	0.390	0.448	0.509
		Capital spending-to-agricultural output ratio, agricultural transformation industry	0.040	0.082	0.125	0.170	0.217	0.265	0.316	0.369	0.423	0.480
	Boost intra-Africa agricultural trade	Exports and imports of agricultural commodities, ratio to GDP	0.280	0.282	0.283	0.285	0.286	0.287	0.289	0.290	0.292	0.293
		Agriculture and food exports-to-imports ratio	3.024	3.082	3.141	3.200	3.259	3.317	3.376	3.435	3.493	3.552
		Processed food, share to total agriculture and food exports	0.200	0.213	0.226	0.239	0.252	0.264	0.277	0.290	0.303	0.316
		Intra-Africa exports and imports of agricultural commodities, growth	0.124	0.263	0.420	0.596	0.794	1.016	1.267	1.548	1.863	2.219
		Intra-Africa agriculture and food trade cost	-0.098	-0.186	-0.266	-0.338	-0.403	-0.461	-0.514	-0.562	-0.605	-0.643
	Increase Local food consumption	Food Import Dependency Ratio	0.056	0.055	0.055	0.054	0.054	0.053	0.053	0.052	0.052	0.051
		CPI Locally Produced Food	-0.047	-0.092	-0.134	-0.175	-0.214	-0.251	-0.286	-0.320	-0.352	-0.382
		CPI Imported Food	-0.002	-0.004	-0.006	-0.008	-0.010	-0.012	-0.014	-0.016	-0.018	-0.020

ANNEX B: MALABO COMPLIANT RESULTS FRAMEWORK FOR KENYA (CONT.)

Goal	Result	Metric	Target									
			2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Increase agricultural investments & financing	Increase public agricultural expenditure	Public investment expenditures, growth	0.189	0.414	0.681	0.999	1.376	1.825	2.359	2.994	3.749	4.647
		Public investment expenditures, foreign financing share	0.058	0.080	0.102	0.124	0.146	0.167	0.189	0.211	0.233	0.255
		Public investment expenditures, agriculture share	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
	Increase private agricultural expenditure	Private investment national, growth	0.059	0.121	0.188	0.258	0.332	0.411	0.494	0.582	0.675	0.774
		Private investment national, share foreign investment	0.661	0.658	0.656	0.653	0.651	0.649	0.646	0.644	0.641	0.639
		Private investment in agriculture, growth	0.020	0.040	0.061	0.082	0.104	0.126	0.149	0.172	0.195	0.219

ALL IFPRI DISCUSSION PAPERS

All discussion papers are available **here**

They can be downloaded free of charge

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
www.ifpri.org

IFPRI HEADQUARTERS
1201 Eye Street, NW
Washington, DC 20005 USA
Tel.: +1-202-862-5600
Fax: +1-202-862-5606
Email: ifpri@cgiar.org

IFPRI AFRICA REGIONAL OFFICE
Titre 3396, Lot #2 BP 24063
Dakar - Almadies Senegal
Tel.: +221-33-869-9800
Email: ifpri-dakar@cgiar.org