Chapter 7

Rwanda

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Despite a remarkable transition to peace and development over the past 10 years, Rwanda is still marked by the consequences of the 1994 genocide. Gross domestic product (GDP) growth averaged 7.3 percent per year between 1995 and 2006, and public investment has picked up and reached 9.4 percent of GDP in 2007. With security and political stability restored and the business environment improved, private investment has risen from 6 percent in 2001 to an estimated 9 percent of GDP in recent years (Rwanda, MINECOFIN 2008). Progress has also been made in improving education and health indicators. For examples, the number of primary school students rebounded to pre-genocide long-term levels only five years after the conflict. Today Rwanda's gross primary school enrollment ratio is higher than in most other Sub-Saharan countries with similar income levels, and the number of students in secondary school has almost tripled since 1996 (Lopez and Wodon 2005). Moreover, in terms of health indicators, World Bank (2008a) estimates that, while infant mortality increased from 85 to 137 per thousand between 1988–92 and 1992–94, it has since receded to 97.5 per thousand in 2006.

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Despite impressive progress in Rwanda, severe challenges remain for longer-term development. The destruction of human and physical capital that ensued during the genocide greatly reduced productivity, household incomes, and government revenues, leading to an increase in poverty. Moreover, the consequences of armed conflicts for an economy can be long lasting, even if growth rates recover within a short period after conflict. By 2006 per capita income in Rwanda, measured by real GDP, was still lower than before the genocide. Challenges also arise from the country's lack of natural resources and social and institutional constraints. Being landlocked and resource poor, Rwanda is often grouped with those African countries facing the most serious binding constraints to development (Ndulu and O'Connell 2006). In addition, a history of social division and ethnic diversity increases the country's need for ethnically neutral institutional development (Bigsten and Isaksson 2008). Thus, with per capita income of US$260 per year and about 60 percent of the population living on less than US$1 per day, Rwanda today remains poor and underdeveloped. Economic growth must accelerate if Rwanda is to meet its development goals of halving its national poverty rate and thereby achieving the first Millennium Development Goal (MDG), even by the country's revised 2020 deadline.

To address these development challenges, the Government of Rwanda has firmly committed itself to reducing poverty and stimulating higher and more sustainable economic growth, as articulated in its overarching strategy *Vision 2020* (Rwanda, MINECOFIN 2000) and in its first Poverty Reduction Strategy Paper (PRSP) (Rwanda, MINECOFIN 2002). Agriculture features prominently in both strategy documents. According to *Vision 2020,* agricultural transformation is expected to boost off-farm growth in both formal and informal sectors, with the effect of reducing the proportion of the population dependent on agriculture from the present 87 percent to 50 percent by 2020. In addition, because of low agricultural productivity, there is considerable scope for substantial income gains in the short run by investing in higher productivity. In the most recent PRSP (Economic Development and Poverty Reduction Strategy 2008–12 [EDPRS]), the focus on agriculture, particularly on improving productivity and infrastructure, has been further strengthened, and the distributional effect of growth is seen to matter more over time (Rwanda, MINECOFIN 2008).

In light of these agricultural transformation objectives, this chapter evaluates the effectiveness of different agricultural growth strategies in reducing national poverty in Rwanda. More specifically, we seek to answer three policy-related questions: (1) Which agricultural growth sources are the most pro-poor? (2) How can economic linkages between agriculture and nonagriculture be strengthened such that nonfarm activities become a more important income source for poor households? (3) What are the most cost-effective public investment choices for stimulat-

ing shared growth and poverty reduction? To address these questions, we apply the recursive dynamic computable general equilibrium (DCGE) model described in Chapter 2 to the Rwandan economy. The third question is addressed by using a combination of cross-country analysis and detailed country-specific investment costing and analysis. The latter is unique to the Rwandan case study and provides an alternative approach to either the top-down or full integration approaches used in the other country studies in this volume.

The chapter is structured as follows. We first describe the structure and past performance of the agricultural sector in Rwanda and review the country's main agricultural and development strategies. We then describe the data sources used to calibrate the Rwandan DCGE model and describe some "stylized facts" about Rwanda's agricultural sector that emerge from this new economywide database. The model results are then presented for the baseline growth scenario, the accelerated agricultural growth scenarios, and the detailed investment analysis. The final section draws together our findings from the Rwandan case study and identifies policy options for realizing agricultural growth and poverty reduction.

Agriculture in Rwanda

Agriculture's Economic Performance

Agriculture features prominently in the Rwandan economy and accounts for about two-fifths of total GDP. Agricultural commodities, mainly tea and coffee, generate 70–90 percent of total export revenues. The modest production gains achieved in coffee and tea in recent years have allowed Rwanda to broaden its revenue base, but the per capita value of commodity exports remains far lower than the average for Sub-Saharan Africa. In addition to its importance for food security, agriculture is also the largest source of employment in Rwanda and is the country's main comparative advantage. Experiences in other countries have also shown that agricultural productivity growth is the primary driver of poverty reduction, both through its direct effects on farmers' incomes and through its indirect effect on the reduction of food prices (Thirtle, Lin, and Piesse 2003; Byerlee, Diao, and Jackson 2005; Bezemer and Headey 2008).

Despite agriculture's important role in Rwanda, the sector faces huge challenges. The recent performance of Rwanda's agricultural sector has been disappointing. Productivity in many staple crops and the livestock sector has remained flat, while the average farm size has declined. With many rural households surviving on subsistence farming, and few growing commercial crops, income growth is stagnant for many farmers. Furthermore, Rwanda is the most densely populated country in Sub-Saharan Africa, with 574 inhabitants per square kilometer of arable land even

in the late 1980s (Clay 1996). Virtually all arable land in the country is used for agricultural purposes. The country has one of the highest population growth rates in the world, its population having doubled from the 1970s to the 1990s. About 800,000 people (more than 10 percent of the population) died in the genocide of 1994 (Verwimp 2003), causing the population to decline by 23 percent during 1990–95. However, by 2006 the country's population was already 34 percent more than its highest pre-genocide level. Given that Rwanda is so densely populated, the country's emphasis on traditional subsistence farming and its high population growth have left many farmers' incomes even lower than they were during the pre-genocide period.

Lack of new land for agriculture is also due to the geographic and ecological constraints of the country. The country is dotted with steep hills, where altitudes and slopes can change dramatically within "shouting distance" (Blarel et al. 1992). Land scarcity has compelled farmers to cultivate fragile, steep-sloping holdings, which has contributed to declining agricultural productivity and has huge environmental costs. The household-level analysis of Clay et al. (1995) shows that on highly eroded farms, an additional hectare produces 20–36 percent less than on farms with little erosion. According to the Rwandan Environment Management Authority (REMA), without applying such conservation measures as terracing, the cultivation of land on steep slopes has caused substantial soil erosion that has resulted in 1.4 million metric tons of soil lost each year. This erosion reduces the country's capacity to feed 40,000 people annually and is equivalent to 1.9 percent of the country's total GDP (REMA 2009). It is thus particularly urgent for Rwanda to emphasize an agricultural strategy that promotes environmentally sustainable land management, investments in soil conservation and fertility, and improvement in land productivity through various channels.

Structure of the Agricultural Sector

The new economywide database constructed for the DCGE model (described later in this chapter) permits a detailed analysis of the structure of agriculture in Rwanda in 2006. Based on these data, several stylized facts emerge. The first is that Rwandan agriculture is characterized as a sector with few export opportunities besides the two traditional export crops, tea and coffee. This restriction is to be expected for a landlocked country with poorly developed roads and other infrastructure. Approximately 1.4 million rural households depend mainly on agriculture for their livelihoods, and almost two-thirds of their products are destined for their own home consumption. According to the economywide database, very few crops other than tea and coffee are exported. Moreover, the value of these exported crops is a tiny percentage of total production. One of the most important export crops other than tea and coffee is pyrethrum. Because pyrethrum is still a very small sector, we refer to it and other

small export crops as simply "other export crops." Other nontraditional exports include vegetables and fruits, but the share of exports in total production is small: 0.62 percent for vegetables and 0.15 percent for fruits.

According to Fowler et al. (2007), some staple crops have comparative advantage in regional trade. Regional export-oriented crops include potatoes, rice, wheat, maize, and soybeans. Without information on informal cross-border trade, the economywide database captures only a very small portion of such trade in potatoes, accounting for 0.40 percent of potato production. Banana production is dominated by cooking bananas, but it also includes beer and fruit bananas. They are also exported (mainly fruit bananas), but the share of exports in total banana production is only 0.01 percent. Rwanda does export some livestock products, but the share of such exports in total livestock production is very small (3.2 percent). Lack of market access for exports will become a constraint when growth in agriculture accelerates. This concern will be further analyzed in the model simulation analysis.

Although about 90 percent of the economically active population has been engaged in agricultural activities, some food products depend on imports to meet domestic demand in Rwanda. Currently, imports of wheat, maize, and rice account for 20–36 percent of domestic consumption. During urbanization, population growth, and per capita income growth, imports of these grain products, which are often income elastic in the early stage of development, are expected to further increase if domestic production cannot keep up with the growth in demand for them.

The second stylized fact is the extremely small holding size for farmers. With the highest population density in Africa, the average rural households' landholding is 0.75 hectares (ha) and per capita landholding is 0.15 ha. With such a small average size, smallholder farmers are expected to dominate the agricultural economy. The second Household Living Conditions Survey (EICV2) (NISR 2006) shows that 77 percent of rural households have less than 1 ha per household, the average household holding size for this group of households being 0.37 ha. Limited access to land is a key indicator explaining income inequality and poverty in the country, where the dominant source of income in the rural area is from the agricultural sector. A simple regression shows that there is a strong correlation between the size of landholding and household income. Table 7.1 summarizes the population distribution by landholding size. It indicates the importance of productivity-led smallholder agricultural growth in poverty reduction.

The third stylized fact is the dominance of foods in household expenditure. With a low income level for most households, an average Rwandan rural household spent 77 percent of its income on food consumption in early 2000s (the first Household Living Conditions Survey [EICV1] took place in 1999–2001) (Rwanda, MINECOFIN 2003) and 68 percent in more recent years (EICV2 took place in 2005–06). Food accounted for 47 percent and 43 percent, respectively, of total

Table 7.1—Population distribution (percent)

Source / indicator	Rural: Households with less than 1 ha of cropland	Rural: Households with more than 1 ha of cropland	Rural total	Urban total	National total
EICV1 (1999–2001)					
Population share	65.0	24.6	89.5	10.5	100.0
Poor population share	76.6	20.9	97.5	2.5	100.0
Poverty rate	71.1	51.4	65.7	14.3	60.3
EICV2 (2005–06)					
Population share	61.1	22.3	83.4	16.6	100.0
Poor population share	73.3	18.3	91.6	8.4	100.0
Poverty rate	68.2	46.7	62.5	28.7	56.9

Source: Authors' calculations based on EICV1 (1999–2001) and EICV2 (2005–06) (Rwanda, MINECOFIN 2003 and 2007).

Notes: The poverty rate is the proportion of the population with per capita consumption below the poverty line. ha = hectare. EICV1 and EICV2 = first and second Household Living Conditions Surveys.

consumption spending for an average urban household in these two time periods. Aggregation of rural and urban households into 10 groups by level of per capita income shows, not surprisingly, that food consumption accounts for a much higher share of total spending among poor households. For example, the poorest 20 percent of rural households must spend 86 percent of their income on food; for the poorest 20 percent of urban households, the share of total spending on food is 65 percent. Income elasticities were estimated following the approach of King and Byerlee (1978). The results show that the marginal budget share for food consumption declines only slightly, from the current share (average budget share) of 59.3 percent (in EICV2) to 56.7 percent for the country as whole. That is to say, for each increase in income of 100 Rwandan francs (RWF100), an average Rwandan would spend additional RWF56.7 on food and the rest on other kinds of consumption. This observation further indicates the importance of promoting agricultural growth for improving food security in the country.

The fourth stylized fact is the diverse diet and agricultural production structure in the country. For example, root and tuber crops are the most important staples in the country. In South Province, West Province, and North Province these crops account for more than 40 percent of agricultural production (in value terms), and they account for 25 percent in East Province. Most cereals are produced in the east, and they account for a higher share of the region's overall agricultural production than in the other regions. In terms of high-value crops, coffee and tea are produced outside East Province, predominantly in the western part of the country. However,

the share of vegetable and fruit production is the highest in the East Province, although the current export opportunities for these crops are small.

The economywide database developed for this study disaggregates the agricultural sector to the district level, including the 28 districts that report agricultural production. Production diversification is more obvious at the district level. There are 18 districts that are the most important producers of the country for at least one crop. For example, 38–100 percent of production of export crops (such as tea, coffee, and other cash crops) is concentrated in just three districts. Rice and wheat production is also relatively concentrated, with the three most important districts producing 48.4 percent (rice) and 58.7 percent (wheat) of national production of these crops. The next two most concentrated staples are maize (31.6 percent) and potatoes (33.3 percent). For the remaining crops, the top three producing districts account for less than one-third to one-fifth of national production. The concentration of production of export and high-value staple crops in a few districts indicates that the gains from promoting growth in such crops are unlikely to be distributed evenly among districts and rural households. Whether such uneven distribution in high-value production affects income distribution and poverty reduction is clearly a policy issue.

Agricultural Policies and Development Strategies

This section briefly reviews Rwanda's recent agricultural strategies. The first comprehensive strategic document—*Vision 2020*—was published in 2000 as a result of a broad national consultative process that took place in 1998–99 (Rwanda, MINECOFIN 2000). The major aspiration of *Vision 2020* is to transform Rwanda's economy into a middle-income country with per capita income of US$900 per year by 2020 (from less than US$300). Transformation of agriculture from its current traditional and subsistence system into a productive, high-value, market-oriented sector with forward linkages to other sectors was emphasized in the document. *Vision 2020* rightly points out that the most important binding constraint of Rwandan agriculture is its low productivity associated with a traditional subsistence farming system, not the average size of landholdings. Agricultural policy will focus on promoting intensification to increase production. *Vision 2020* has provided direction for the country's agricultural development strategy (in the form of eight key policy areas that need urgent attention to bring about the transformation). However, because it is a rather short document (25 pages), there is no detailed plan in *Vision 2020* for any of these policy areas.

In 2002 Rwanda published its first PRSP covering the period up to 2005 (Rwanda, MINECOFIN 2002). In the PRSP, the importance of rural development and agricultural transformation was emphasized and moved to the top of a list of six priority areas (it was the second priority in *Vision 2020,* after reconstructing the

nation and its social capital on the basis of good governance and a capable state). Moreover, unlike in *Vision 2020,* agriculture has been integrated into a broad concept of rural economic transformation in PRSP 2002. In addition, raising agricultural productivity and rural income, including generating opportunities to earn income outside agriculture, have become general goals for this transformation (Rwanda, MINECOFIN 2002, 9).

Agriculture has therefore been chosen as the primary engine of economic growth, and it will be driven by increased fertilizer use (targeted to contribute 75 percent of agricultural growth), along with improvement of wetland management and crop intensification. The PRSP notes that at the current level of technology, smallholder agriculture is the most productive, and the transformation can be achieved by smallholder households who will be supported by energetic public action. The PRSP also emphasizes the increase and diversification of exports, including agroprocessing exports, to find new engines of growth. The most important development in the PRSP is an explicit discussion on the linkages between agriculture and environmental sustainability. The decline in soil fertility in the country "is compounded by soil erosion and the reduction of the water table in some areas and hence agricultural intensification must be accompanied by environmental actions to manage water flows, control soil erosion and improve the soil structure" (Rwanda, MINECOFIN 2002, 36).

As a part of the action plans discussed in PRSP 2002, an agricultural sector strategy was developed in 2004 through the National Agricultural Policy (Rwanda, MINAGRI 2004a) and the Strategic Plan for Agricultural Transformation in Rwanda (PSTA) (Rwanda, MINAGRI 2004b). The first part of PSTA provides an overview of typology and characteristics of agricultural farms, sector institutions, rural poverty, food and nutrition, land and labor productivity, and the role of women in agriculture. It also contains an analysis that covers broad aspects of agriculture, including natural resource management and water and soil conservation; crop and animal production and commodity chains; farmers organizations; agribusiness; infrastructure; legal and regulatory framework; and financing, coordination, monitoring, and evaluation of the agricultural sector. The second part of PSTA details the strategic plan, priority programs, expected outputs, and the contribution of other sectors to support agricultural development. The third part of PSTA provides an action plan and estimates financial requirements. Although 10 strategic aspects of agricultural and rural development are highlighted in the second part of PSTA, the document correctly emphasizes that this strategy has to be progressive, flexible, and dynamic.

PSTA comprises four principal priority programs with 17 subprograms. Their expected results appear in the quantified objectives of the third part of PSTA as the Plan of Action. PSTA also emphasizes the interrelations between the four principal

priority programs: (1) intensification and development of sustainable production systems, (2) support to the professionalization of producers, (3) promotion of commodity chains and development of agribusiness, and (4) institutional development. Each principal priority program further comprises subprograms, and for each subprogram the document provides a brief synthesis of the diagnosis of the current situation, the strategy, specific objectives or targets, and specific actions. For example, in the first principal priority program (intensification and development of a sustainable production system), there are five subprograms: (1) sustainable management of natural resources and conservation of water and soils; (2) development of integrated agricultural and livestock systems and promotion of specialized intensive animal husbandry; (3) development of marshland and irrigation; (4) supply and use of agricultural inputs; and (5) establishment of food security, implementation of risk management, and evaluation of vulnerability.

The PSTA also includes a table providing indicative and allocated fund estimates for each program and subprogram. However, there exists a significant gap between the demands (indicative funds) and supply (allocated funds) in the estimates. Although this gap is explicitly presented in the table, the document does not discuss how to fill this gap. This raises the question of how to actually prioritize resource allocation to different programs facing a budget constraint that was already clear when the plan was developed, and hence, how to implement these programs when faced with such financial constraints.

There is no doubt that Rwanda's agricultural strategic plan is a comprehensive document supported by strong evidence developed through a broad consultation process. However, given the constraint of limited financial resources facing the government, how to sequence and prioritize the programs remains a challenge. Moreover, although agriculture is known to be an engine of growth that is generally pro-poor, it still requires empirical evidence to explicitly measure the linkages of growth at the subsector level and overall economic growth and poverty reduction. The analysis in this chapter provides some answers for these highly policy-relevant questions. We first simulate a scenario of modest growth in both agricultural and nonagricultural sectors up to 2015, based on the country's historical data.

The Rwandan DCGE Model

Most existing studies on Rwandan agriculture and agricultural policies are at the microlevel and focus on natural resource management. For example, in a study on farm fragmentation Blarel et al. (1992) used farm-level data for 1987–88 for Rwanda's three prefectures and found both drawbacks to and possible benefits from farm fragmentation for farmers. Clay et al. (1995), in collaboration with the Division of Agricultural Statistics (DSA) of the Rwandan Ministry of Agriculture, measured

both the cost of erosion to land productivity and the returns to soil conversation investments using national farm household survey data between 1983 and 1994. Using data from a similar survey for 1991, Clay (1996) analyzed farmers' ability and willingness to invest in conservation and soil fertility technologies. The study done by Roose and Ndayizigiye (1997) analyzed water and soil fertility management to fight erosion in tropical mountains of Rwanda using plot-level data. A study done by Kelly et al. (2001a), using data from an agricultural survey of 2000's first season, further emphasized the importance of anti-erosion investment and use of fertilizers to agricultural productivity, rural income, and food security. Beyond agricultural production, Verpoorten and Berlage (2004) conducted a comparison of rural household strategies used to improve income and reduce poverty. The study of von Braun, de Haen, and Blanken (1991) is much more comprehensive; it measures the effects of commercialization in Rwanda on production, income, employment, consumption, and nutrition using household survey data.

Although these studies provide detailed knowledge about and policy options for the country's agricultural and rural economy, a knowledge gap exists in the literature, because no study explicitly focuses on the linkages between the agriculture/rural sector and the rest of economy. Nor do these studies evaluate the contribution of rapid agricultural growth to poverty reduction, and the public investment required to support such growth. The methods used in the previous studies are unsuitable for analyzing these growth linkage issues. We therefore developed a new DCGE model for Rwanda.

A SAM is the underlying database for a DCGE model. The one developed for this analysis is an extended version of the unpublished 2006 SAM of Rwanda constructed by Arnault (2007). This original SAM was constructed for the national economy and included 51 agricultural and nonagricultural sectors and two primary factors—labor and capital. For the purpose of this study, this SAM has been further disaggregated (see Table 7A.1 in the appendix to this chapter). The key adjustment was to disaggregate agricultural production, households, and primary factors. In our SAM, we first disaggregate all agricultural activities into 30 districts and within each district into two types of farm groups (small farms and medium–large farms) to better capture heterogeneity in production structure across districts. We also disaggregate labor into unskilled agricultural labor, unskilled nonagricultural labor, and skilled labor, and we disaggregate capital into capital and agricultural land. We then further disaggregate capital into sector-specific capital, economywide agricultural capital, and economywide nonagricultural capital. We assume that land cannot be mobile across districts or among farm groups, which implies that there are 56 categories of land.

In addition to disaggregated primary factors and agricultural production, households and their incomes are further disaggregated. Most Rwandan farmers are

involved in staple crop and livestock production, but the opportunities to participate in high-value crop production are not equally distributed among them. For example, tea, one of the country's most important export crops, is only produced in 10 of the 30 districts, mainly in West Province. Moreover, tea is produced by farmers with large landholdings, though small farmers can participate as laborers. In the case of coffee (the other important export crop of the country), 19 districts produce coffee, but the main production area is concentrated in South Province and West Province. With such uneven distribution in export crop production opportunities, if public support concentrates on promoting tea and coffee production and exports, the benefits of such a policy would not be likely to reach those farmers outside areas growing tea and coffee. Without a disaggregated SAM, and hence a disaggregated DCGE model, such uneven distribution in the income gains from tea and coffee promotion policies would be ignored, as well as the impact on poverty reduction of such policies.

The disaggregation of the SAM is based on the information drawn from the EICV2 (NISR 2006) and the Rwanda Agricultural Survey 2006 (Rwanda, MINECOFIN 2007). After disaggregation on the production side, there are 960 production activities for 16 crop sectors (16 sectors · 30 districts · 2 types of farms = 960), 270 production activities for 9 livestock sectors (9 sectors · 30 districts = 270), and 28 nonagricultural sectors defined at the national level. Sixty-two primary factors are distinguished (3 for labor, 3 for capital, and 56 for land). On the demand side, 62 representative household groups: 60 (30 districts · 2 types of farm households = 60) in the rural area and 2 in the urban area. On the demand side, we also consider the difference between consumption met by farmers' own production and consumption met through the market. The first type of consumption reflects a subsistence pattern of agricultural production, which exists alongside smallholder agriculture; such consumption is determined by the production that occurred in each district and farm group. Consumption met by the market is more sensitive to change in prices in the market and income received from both agricultural and nonagricultural activities, which are modeled explicitly in the simulations discussed later.

Baseline Growth Scenario

Because of sharp production declines in 1994 in Rwanda, the year of the genocide, the post-1994 growth rate was comparatively high and has only recently slowed down. According to World Bank (2008a), during the post-genocide period of 1995–2006, growth rates for total GDP and agricultural GDP (AgGDP) were 7.3 and 6.9 percent annually, respectively, whereas growth has slowed in both total GDP and AgGDP in recent years. During 2002–06 the annual growth rate for total GDP was 4.03 percent, and that for AgGDP was 0.53 percent. This poor

growth performance of AgGDP in the recent period is the reflection of the severe drought in 2003 after the above-normal harvest of 2002, followed by another bad year in 2004. Even considering a longer period (for example, 2000–06), the annual AgGDP growth is still low (4.1 percent) compared to total GDP growth (5.4 percent). Data from Rwanda, MINAGRI (2007) show that total crop production grew at 4.7 percent per year during 2001–07. During this period 30–40 percent of crop production growth was due to area expansion, and the remaining 60–70 percent was due to yield increases (the majority of these increases represented a recovery from the declines of 1994). Clearly, such rapid growth is unsustainable, particularly given the land constraint. Consequently, much more modest land-based expansion is assumed in the model, including the promotion of double cropping and intercropping farming practices. Total crop area is assumed to increase by 0.5 percent per year, implying a cumulative increase of about 80,000 ha of cultivated area from 1.69 million ha in 2006 to less than 1.77 million ha by 2015. The growth rates for individual crop yields are chosen to approximate their national average growth rates during 2001–06, with certain adjustments for some crops with particularly high yields during this period (for example, rice grew at 8 percent per year, and vegetables and fruits grew at more than 15 percent).

The base year 2006 was chosen for the model, and the model's business-as-usual (or baseline) simulation indicates that, with modest growth of 3.8 percent in agricultural production together with 5.1 and 5.7 percent annual growth in industry and services, respectively, national GDP grows at 4.8 percent annually, and per capita GDP grows at about 2.9 percent. Crop- or sector-level baseline simulation results are reported in Tables 7.2a and 7.2b (for crop and noncrop sectors, respectively). The model result for the growth rate of national GDP is higher than that for 2002–06 (4.0 percent annually) and slightly lower than that for 2001–06 (5.1 percent annually).

The model results also show a modest reduction in national poverty and an improvement in food security. The poverty rate falls to 46.7 percent by 2015, compared with 60.3 percent in 2001 (EICV1 data) and 57.0 percent in 2006 (EICV2 data), although the rate was higher in rural areas (63.4 percent) than in urban areas (28.8 percent). Such a reduction in the poverty rate together with population growth results in a decline in the number of the poor of only 220,000 from its current level of 5.45 million (that is, to 5.23 million by 2015). The poverty reduction in the model as a result of GDP growth is slightly more optimistic than what was experienced in 1999–2005 between the two rounds of household surveys (EICV1 and EICV2). During this period, per capita GDP grew at 2.3 percent annually, while the national poverty rate fell from 60 percent to 57 percent, which indicates that for every percent annual growth in per capita GDP, the national poverty rate fell by 0.42 percent (not percentage point). In the baseline simulation model, 1

Table 7.2a—Simulated baseline national crop production trends

Sector	Area			Yield			Output		
	2006 (thousands of ha)	2015 (thousands of ha)	Growth rate (percent)	2006 (metric tons/ha)	2015 (metric tons/ha)	Growth rate (percent)	2006 (thousands of metric tons)	2015 (thousands of metric tons)	Growth rate (percent)
All crops	1,692	1,775	0.5						
Wheat	23	25	1.1	0.9	1.2	3.8	20	30	5.0
Maize	115	126	1.0	0.8	1.0	2.8	92	129	3.9
Rice	14	18	3.0	4.5	4.9	0.9	63	89	4.0
Sorghum	170	162	–0.6	1.1	1.5	3.7	187	246	3.1
Potatoes	140	149	0.7	9.2	11.9	2.9	1,286	1,769	3.6
Sweet potatoes	139	136	–0.2	5.6	6.9	2.4	777	940	2.1
Cassava	119	123	0.4	6.3	8.0	2.8	743	988	3.2
Other roots	25	29	1.7	5.0	6.0	2.2	125	177	3.9
Pulses	388	410	0.6	0.8	1.0	2.7	298	402	3.4
Vegetables	51	51	0.1	5.4	7.3	3.5	271	374	3.6
Bananas	366	393	0.8	7.2	10.0	3.6	2,652	3,927	4.5
Other fruits	34	32	–0.6	9.9	14.3	4.1	339	463	3.5
Oilcrops	59	61	0.4	0.6	0.8	3.2	36	50	3.6
Coffee	29	34	2.0	0.7	1.1	4.1	21	36	6.2
Tea	13	16	2.0	1.2	1.7	4.1	16	27	6.2
Other exports	8	9	1.2	19.9	26.5	3.2	162	240	4.5

Sources: Authors' calculations using Rwanda, MINAGRI (2008) for 2006 and the Rwandan dynamic computable general equilibrium model results for 2015.
Note: ha = hectare. Blank cells = not applicable.

Table 7.2b—Simulated baseline national noncrop production trends

Sector	Output, 2006 (RWF million)	Output, 2015 (RWF million)	Annual growth (percent)	Sector	Output, 2006 (RWF million)	Output, 2015 (RWF million)	Annual growth (percent)
Bovine cattle	13	19	4.2	Wood, paper, and printing	4	5	4.1
Sheep and goats	2	3	4.5	Chemicals	7	11	5.5
Swine	1	2	3.8	Nonmetallic minerals	9	13	3.8
Poultry	1	2	4.6	Other manufacturing products	12	16	3.7
Raw milk	8	15	7.3	Electricity, gas, and water	9	14	4.5
Eggs	1	3	7.5	Construction	97	147	4.8
Other livestock	1	3	7.0	Wholesale and retail trade	135	199	4.4
Forestry	39	54	3.8	Hotels and restaurants	12	19	5.3
Fishing	6	9	4.8	Transport	52	95	7.0
Mining	11	16	3.7	Communications	33	66	8.0
Meat, fish, and dairy products	5	8	5.6	Finance and insurance	74	135	6.9
Processed cereals	5	9	6.7	Real estate	90	166	7.1
Processed coffee	8	17	8.3	Business services	26	49	7.2
Processed tea	9	16	6.7	Repair	10	18	7.4
Bakery and processed sugar	1	2	3.9	Public administration	93	133	4.0
Traditional beverages	17	25	4.6	Education	62	91	4.3
Modern beverages	9	15	5.7	Health	20	30	4.4
Tobacco	3	5	3.9	Other personal services	14	21	4.4
Textiles and clothing	5	11	10.3				

Sources: Authors' calculations using the social accounting matrix for 2006 and the Rwandan dynamic computable general equilibrium model results for 2015.
Note: RWF = Rwandan francs.

percent of per capita GDP growth results in a 0.71 percent decline in the national poverty rate. The model results also show that the current gap between supply and demand in the food sector would continue to increase. Imports of maize will double, and rice imports will rise by 70 percent by 2015 from their current levels, making Rwanda increasingly dependent on imports or food aid to meet its basic needs for many staple foods.

Accelerated Growth Scenarios

Quantitative assessment of how the growth in each agricultural subsector will contribute to overall economic growth and poverty reduction is crucial for understanding the role of agriculture in broader development. Recent policy debates on agricultural development in Africa have been about such issues as the role of smallholders and that of food staples versus export crops. Despite numerous Asian case studies that have proved the important role of agriculture in development, there is doubt about whether agriculture can successfully generate enough growth in Africa today (see, for example, Collier 2003; Maxwell and Slater 2003; Ellis 2005). With rapid expansion in international agricultural trade, many see high-value commodities, such as fruits, flowers, and vegetables, as the best opportunities for African farmers. Many African countries are being encouraged to expand into high-value, nontraditional exports and to improve the quality of their traditional tree-crop exports. In Rwanda these sectors, such as coffee and tea, have also attracted more attention and support from the government.

In this section we describe a series of subsector agricultural growth scenarios to specifically address these issues. Based on the actual growth targets at the agricultural subsector level, we quantitatively assess the following important policy issues:

1. What is the contribution of each agricultural subsector to broad growth and poverty reduction goals?

2. Why is staple growth so important for overall economic growth and poverty reduction?

3. How can staples-led growth help the country to meet the Comprehensive Africa Agriculture Development Programme (CAADP) goal of 6 percent growth and achieve the first MDG to halve poverty?

4. What is the role of the export agricultural sector?

5. What is the role of nonagricultural growth in this development process?

Although we can simulate growth targets for each crop and subsector, such isolated growth is almost impossible in reality. Thus, we also describe a scenario (the "CAADP scenario") in which growth occurs simultaneously in all subsectors to meet the targets set by the government. We first discuss the results from this scenario before focusing on individual subsectors.

Agricultural and Total GDP Growth Results

With detailed production targets at the agricultural subsector level developed by the Government of Rwanda, such questions as whether these growth targets can support the broad goal of 6 percent agricultural growth and how such growth contributes to halving poverty by 2015 (that is, the first MDG) remain to be answered. The model simulation shows that if the desired targets at the agricultural subsector level can be achieved, then agricultural GDP would grow by 6.3 percent during 2007–15, thus almost doubling the baseline growth rate. This represents total GDP growth of 6 percent, compared with the 4.8 percent baseline level. If additional yearly growth of 2.8 and 2.4 percent is assumed to occur in the industrial and service sectors, respectively, then linkages between nonagriculture and agriculture boost agricultural growth to 6.5 percent per year, while total GDP growth rises to 7.4 percent per year. At this rate, per capita GDP grows at 5.5 percent annually, thus doubling the baseline rate. With such high growth rates, national poverty falls to 35.5 percent by 2015, which is 24.5 percentage points lower than the rate in 1999 and 11.2 percentage points lower than the 2015 baseline. If such growth trends continue until 2020, the country would be able to achieve its first MDG by halving the 1999–2001 poverty rate of 60 percent, albeit only by extending the deadline for achieving that goal to 2020.

Household Income and Poverty Effects

Growth may not benefit rural households equally. Empirical studies in other countries often show that rapid economic growth does not always result in shared growth (Akita and Kawamura 2002). Differences in poverty reduction and income growth across regions have also been observed in China (Chen and Ravallion 2000; Kanbur and Zhang 2004). Thus, it is essential to further assess the income and poverty effects of agricultural growth at the household level.

In the case of Rwanda, the simulation results indicate that rapid agricultural growth benefits the majority of rural households and that the distribution of benefits is relatively equal. Nevertheless, the household group with the small landholdings appears to benefit less than the household group with medium–large landholdings. In the scenario in which both agriculture and nonagriculture grow, annual income growth for the small-farm group at the national level is 8.5 percent, whereas it is 9.0 percent for the household group with larger landholdings (Table 7.3). Rural poverty falls across provinces and household groups,

Table 7.3—Rural income growth and poverty reduction for two of the farm household groups under the combined agricultural and nonagricultural growth scenarios (percent)

Region	Income growth rate			Poverty rate		
	Baseline (percent)	Combined scenario (percent)	Change (percentage point)	Base-year, 2006 (percent)	In combined scenario, 2015 (percent)	Change (percentage point)
Rural small-farm households						
Kigali	5.27	7.86	2.59	50.4	30.8	–19.6
Southern	5.91	8.44	2.53	72.7	47.4	–25.3
Western	6.09	8.82	2.73	65.6	40.2	–25.4
Northern	5.78	8.37	2.58	66.8	39.6	–27.2
Eastern	5.43	8.09	2.65	54.0	31.0	–23.0
National	5.83	8.47	2.63	64.9	39.9	–25.0
Rural medium- to large-farm households						
Kigali	5.05	7.60	2.56	50.4	32.9	–17.5
Southern	6.98	8.97	1.99	70.2	42.5	–27.7
Western	7.47	9.77	2.31	63.2	39.9	–23.3
Northern	7.06	9.35	2.29	58.8	33.5	–25.3
Eastern	5.77	8.43	2.66	48.7	24.1	–24.6
National	6.65	9.03	2.38	58.4	33.1	–25.2

Source: Rwandan dynamic computable general equilibrium model results.
Note: The poverty rate is the proportion of the population with per capita consumption below the poverty line.

but at the national level poverty falls more among the group with larger landholdings than among the small-farm group. As the initial poverty rate is already higher among small farmers, the difference in the poverty rate between these two types of rural households is further widened by 2015. At the provincial level, the poverty rate is highest in the South Province for both household groups. Although the initial poverty rate of the southern small-farm group is 2.5 percentage points higher than that of the southern large-farm group, the poverty gap between these two groups increases to 4.9 percentage points by 2015.

Subsector Growth and Poverty-Reduction Impacts

The different poverty-reduction effects of growth at the province level and among different types of farm households relate to the different income sources of farmers and the local agricultural production structure they face. Thus, as differing growth–poverty linkages can occur in the agricultural subsector, it is important to understand such linkages when designing pro-poor growth strategies. For this purpose, the poverty–growth elasticity was calculated to enable direct comparison of the various poverty-reduction outcomes. This elasticity was calculated for the two broad agricultural products—staple food and export crops—as well as for each individual crop or livestock product for which targeted growth was individually simulated.

Although agricultural growth is generally pro-poor, a gap in the poverty–growth elasticities between staple crops, such as grains and roots, and agricultural exports indicates the importance of staples for poorer rural households. If economywide growth is led by growth in grain crops, each 1 percent additional growth in per capita GDP leads to an additional 1.74 percent decline in the national poverty rate. The growth–poverty-reduction effect is particularly large in the case of maize, which has an elasticity of –2.39 (Table 7.4). In contrast, if economywide growth is led by growth in export crops, including both traditional export crops (such as coffee and tea) and nontraditional ones (such as vegetables and fruits), a 1 percent additional growth in per capita GDP reduces the national poverty rate by 1.68 percent.

The model results indicate that putting staples at the top of the agenda can promote broader economic progress and poverty reduction in Rwanda. This is true in general in many African countries, as smallholders comprise more than 70 percent of the continent's farmers (Johnson, Hazell, and Gulati 2003). A wide range of research has also demonstrated the importance of food staples in driving growth and contributing to a dynamic structural transformation of rural economies (Byerlee, Diao, and Jackson 2005; Bezemer and Headey 2008; World Bank, 2008b; Diao, Hazell, and Thurlow 2010). Acceleration in staples production has also been found to produce secondary and tertiary effects on the broader economy by reducing food prices for urban consumers, curbing overall inflation, and releasing scarce foreign exchange for the importation of goods that are typically unsuited to production in

Table 7.4—Poverty-reduction–growth elasticities

Sector driving additional growth in gross domestic product	Elasticity
Maize	–2.39
Rice	–1.86
Wheat	–1.60
Cassava	–1.60
Potatoes	–1.40
Sweet potatoes	–1.65
Pulses	–2.59
Bananas	–2.05
Oilseeds	–2.17
Coffee	–1.81
Tea	–1.63
Other export crops	–2.27
Poultry	–0.45
Other livestock	–1.38
Fishing	–2.11
Grains	–1.74
Root crops	–1.54
Livestock	–1.35
Export crops	–1.68
Agriculture	–1.53
Agriculture with transport	–1.37
Nonagriculture	–0.49
All sectors	–0.97

Source: The Rwandan dynamic computable general equilibrium model results.
Note: Elasticity is the percentage reduction in the national poverty rate following a 1 percent increase in per capita total gross domestic product. The poverty rate is the proportion of the population with per capita consumption below the poverty line.

Africa (Diao et al. 2007). And in the longer run the productivity growth in staples agriculture will facilitate a more fundamental transformation in the broader economy through new opportunities for industry (for example, agroprocessing), growth opportunities for rural nonfarm activities (Haggblade, Hazell, and Reardon 2007), increased regional and international trade, and new employment options through expanded migration.

Agricultural Prices and Market Constraints

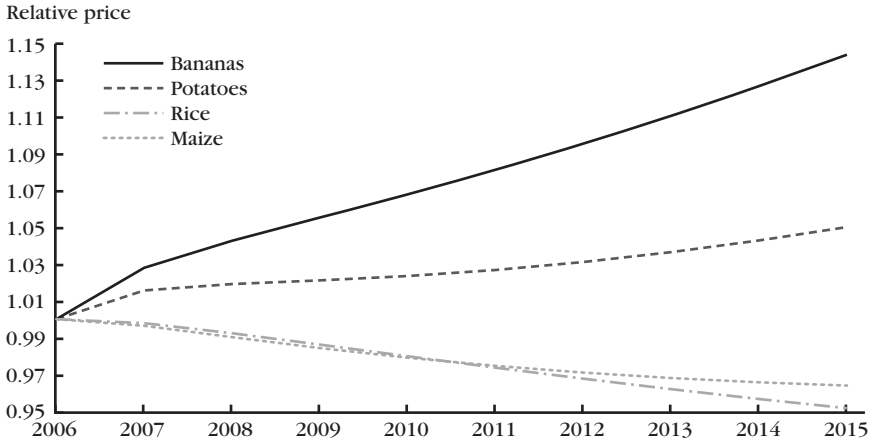
Growth may not always benefit producers, especially when it is unbalanced and occurs in only a few agricultural subsectors. When growth targets are set too high for some agricultural production, there is not enough demand from domestic markets, or it is difficult to export to balance increased supply, prices can fall significantly. This drop may hurt some farmers if they cannot adopt more productive

technology in their production process. For this reason, it is necessary to look at the price effect of growth, particularly for those agricultural products broadly grown by smallholder farmers.

As shown in Figure 7.1, prices for most staple crops will either not decline or decline only modestly if agricultural and nonagricultural sectors grow together. This result is consistent with the information drawn from the two rounds of household living conditions surveys (EICV1 and EICV2) discussed above. Given the current extremely low level of income (and hence consumption) in Rwanda, the demand for staple crops increases with income growth if broad growth can bring more income to the majority of rural and urban households, particular poor households. The domestic market will have to become the dominant destination to absorb the increased supply for most staple crops. In fact, imports of maize actually grow quite rapidly, driven by increased food and feed demand, indicating additional room for further growth in maize production. Similarly, the domestic price for rice is expected to fall modestly, causing import substitution. Although domestic demand for rice doubles over nine years in the simulation, the ratio of imports to the domestic consumption falls from 40 percent in 2006 to less than 30 percent by 2015. This is also important for the country to help reduce dependence on the import of staple foods, and hence, improve food security at the national level.

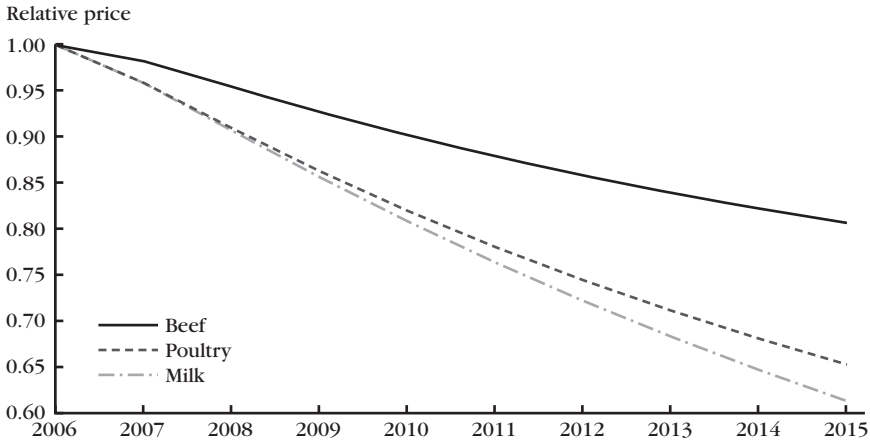
Figure 7.2 displays the changes in prices for selected livestock products. As the growth targets are very high for these commodities, it is not surprising to see that, although the income elasticity is also high for these commodities, prices for them fall dramatically; for example, poultry and milk prices fall by 35–40 percent over the nine

Figure 7.1—Prices of selected staples in the combined growth scenario



Source: The Rwandan dynamic computable general equilibrium model results.
Note: Prices are normalized to 1.0.

Figure 7.2—Prices of selected livestock products in the combined growth scenario



Source: The Rwandan dynamic computable general equilibrium model results.
Note: Prices are normalized to 1.0.

years. Starting from a very small base, poultry and milk production and consumption will have double-digit growth rates during this period. Declining poultry and milk prices benefit consumers, but these low prices may push some small farmers out of production, unless they significantly improve their productivity.

As discussed above, Rwanda depends heavily on agriculture for export revenues. Agricultural exports account for 90 percent of total exports. This situation will be further enhanced with rapid growth in export sectors, resulting in the growth of total agricultural exports by 13 percent each year. In contrast, agricultural imports grow much more slowly, at less than 7 percent, because of import substitution in many agricultural food commodities. Although nonagricultural exports grow more rapidly than the nonagricultural imports, the total value of nonagricultural exports is much smaller than that of imports. This imbalance results in an increased deficit in nonagricultural trade. Thus, the agricultural trade surplus becomes increasingly important to finance nonagricultural imports. When both agricultural and nonagricultural sectors grow in tandem, the ratio of agricultural trade surplus to nonagricultural trade deficit rises from its current value of about 0.08 to 0.29 by 2015.

Agricultural Investment Analysis

Achieving the growth required for Rwanda's agricultural sector to meet both CAADP growth and MDG poverty-reduction targets is a challenging task. In addition to an improved policy environment, public investment is instrumental not only in

improving public services and provision (such as research and extension, rural infrastructure, and education) but also in attracting private investment and inputs. The following discussion focuses on public sector spending on agriculture required to achieve these goals and the potential returns to investments in different subsectors of agriculture.

The previous analysis indicates that agricultural GDP could grow at more than 6 percent annually over nine years in the simulation if agricultural commodity or subsector growth can reach national targets identified by the Government of Rwanda. These growth targets are consistent with CAADP goals and will significantly reduce poverty. The model results show that with more than 6 percent growth in agriculture together with rapid growth in the nonagricultural sector, Rwanda will be able to achieve the first MDG of halving poverty by 2020.

To promote more rapid agricultural growth and greater poverty reduction, the Government of Rwanda has already committed to increasing its investment in agriculture, and many agricultural development programs are being implemented. Moreover, the government has also increased investment in rural infrastructure, markets, and supply chains to improve the external environment for agricultural growth and rural development. Such large-scale public investment is not only necessary for agricultural growth and rural development but is also a precondition for the private sector, including farmers, to increase their investments. All these interventions and investments will build a solid foundation for enhanced agricultural growth, but the short implementation period makes ex post assessment of the impacts of these endeavors on future growth difficult. For this reason, an ex ante approach is developed for this chapter. We first focus on the amount of public investment in agriculture required for achieving the growth targets discussed in the previous section. We then introduce the newly developed ex ante approach and apply it to assess the potential returns of agricultural investment and the relationship between targeted growth and increased agricultural investment at the subsector level.

Estimating Total Spending Required for Agricultural Growth

Official national agricultural spending data are only available for 2001–06; additional data (1995–2000) were drawn from IMF (2004). The estimated elasticity of agricultural growth with respect to agricultural spending during 1995–2005 is 0.17. This elasticity is much lower than the African average of 0.366, which is based on cross-country estimations using a much longer data time series (Fan, Yu, and Saurkar 2008). Because of Rwanda's recent history and the large amount of spending required to recover basic agricultural production in genocide-affected areas, the estimated elasticity for agricultural spending–agricultural growth may not represent the true relationship in the future. Moreover, many productive investment projects

were initiated only recently, and their potential effects on agricultural growth cannot be captured in an econometric analysis. For these two reasons, the elasticity based on the cross-country study is also used in calculating the required levels of public spending (Table 7.5).

Two sets of values are reported, corresponding to the two different agricultural growth scenarios: the CAADP scenario and a scenario corresponding to the first MDG scenario in Table 7.5. As discussed above, 6.5 percent of annual growth in AgGDP combined with a similar growth rate in the nonagricultural sector results in total GDP growth of 7.4 percent annually in the MDG scenario. Required agricultural spending in this scenario is reported in columns 4 and 5 of Table 7.5; required spending corresponding to the CAADP scenario is reported in columns 2 and 3. Agricultural growth is 6.2 percent in this scenario. A 6.2 percent increase in AgGDP per year from 2007 to 2015 requires associated growth in agricultural investment (represented by the agricultural development funds) at 35.9 percent annually using the low elasticity and 18.4 percent using the high elasticity. Assuming

Table 7.5—Estimated resource allocation to the agricultural sector (percent)

		To reach CAADP target		To reach first MDG	
Category	Baseline, 2005–15 (1)	Low elasticity (2)	High elasticity (3)	Low elasticity (4)	High elasticity (5)
Total GDP growth rate	4.6	6.2	6.2	8.0	8.0
AgGDP	4.2	6.2	6.2	8.8	8.8
Non-AgGDP	4.8	6.2	6.2	7.2	7.2
Total spending growth rate	10.8	8.2	6.7	12.2	8.3
Agricultural spending	–6.5	30.3	15.2	45.6	22.6
Agricultural developmental spending	–5.8	35.9	18.4	52.3	26.8
Nonagricultural spending	11.8	6.3	6.3	7.4	7.4
Agricultural spending/total spending	4.92				
2010		6.6	4.4	9.2	5.2
2015		17.6	9.5	34.5	12.0
Agricultural spending/AgGDP	3.2				
2010		4.7	3.0	6.3	3.5
2015		14.1	4.6	30.7	6.5
Nonagricultural spending/Non-AgGDP					
2015	24.9	44.1	44.1	44.1	44.1
Total spending/GDP					
2015	26.1	32.1	28.3	38.3	27.9

Source: Authors' calculations using the Rwandan dynamic computable general equilibrium model and investment analysis results.

Notes: AgGDP = agricultural gross domestic product. CAADP = Comprehensive Africa Agriculture Development Programme. GDP = gross domestic product. MDG = Millennium Development Goal. Blank cells = not applicable.

that the government's allocation to nonagricultural sectors is proportional to nonagricultural GDP and that nondevelopmental spending on agriculture is proportional to AgGDP, the total government budget is estimated to grow at 6.7 percent using the high elasticity and at 8.2 percent using the low elasticity.

The spending growth estimate is consistent with the average growth in the total government budget observed in recent years, but the agricultural spending requires much faster growth than in the past. Because of more rapid growth in agricultural spending than in the total spending growth, the agricultural spending share will rise to 4.4 or 6.6 percent in 2010 and 9.5 or 17.6 percent in 2015, where the lower number is for the high elasticity and the higher one is for the low elasticity (Table 7.5, columns 2 and 3). Whether the government needs to meet requirements of the Maputo Declaration of allocating at least 10 percent of its total budget to agriculture depends on whether agricultural spending can stimulate agricultural growth efficiently. With lower efficiency (that is, low elasticity pertains), the government needs to allocate 18 percent of its total budget to agriculture by 2015, but if spending is more efficient (that is, high elasticity is appropriate), about 10 percent of the total government budget would be needed to support 6 percent annual agricultural growth.

Six percent annual agricultural growth for nine years is insufficient for the country to meet the goal of halving national poverty by 2020. Instead, a growth rate of 6.5 percent per year during 2007–20 is needed. Estimates of the required spending to achieve this level of growth are provided in Table 7.5 (columns 4 and 5), indicating that agricultural spending needs to grow at the extremely high rate of 45.6 percent annually (2007–15) if investment has a low elasticity, or 22.6 percent if the investment is more efficient. Assuming that growth in nonagricultural spending is proportional to nonagricultural GDP and that nondevelopmental spending on agriculture is proportional to AgGDP, then the total government budget would grow at 8.3 or 12.2 percent annually, depending on whether the elasticity was high or low, respectively. The share of agricultural spending would rise to 5.2–9.2 percent in 2010 and 12.0–34.5 percent in 2015, again based on which elasticity is realized.

Although the required rate of growth in public resources allocated to the agricultural sector seems unrealistically high, the resulting shares of agricultural spending are not uncommonly high based on the experiences of many Asian countries in their early stages of development. The analysis here indicates one of the important challenges facing the Rwandan government in prioritizing public fund allocation, as it has shown an inconsistency between the current budget allocation and the role of agriculture as the engine of overall growth and the most important contributor to poverty reduction proposed in government strategic documents (Rwanda, MINECOFIN, 2000, 2002, 2008). On a positive note, the government has already

recognized such inconsistency and has started to increase the allocation to the agricultural sector and rural development in the second EDPRS for 2008–12. However, there is still a significant gap between required increases and planned increases in agricultural spending. This analysis also raises an important issue of improving the efficiency of public spending. When the spending efficiency can be improved to a level representative of the African average, growth in required agricultural spending as well as share of agricultural spending in total budget can be cut by more than half. Increasing the efficiency of public investment requires more studies on institutional and governance capacity and policy implementation process, which is important but goes beyond the scope of this chapter.

Assessing Investment Priorities by Estimating Potential Returns to Investment

Estimating the public resources needed to reach the overall agricultural growth target is important, but prioritizing investments is equally important. To prioritize the allocation of public investment, it is necessary to measure the returns to investment. Public investment will generate externalities and directly and indirectly affect broad economic performance. Hence, it may underestimate the impact of public agricultural investment if the gains are narrowly measured for individual sectors that directly benefit from the interventions. Moreover, as we have shown in the previous section, agriculture-led growth is pro-poor, and the relationship between public investment in agriculture and poverty reduction needs to be taken into account when the impact of agricultural investment is assessed. In this section we combine the public investment analysis with the DCGE model to assess the potential returns to agricultural investment from an economywide perspective.

As previously mentioned, constrained by the short period of existing investment data in Rwanda stemming from historical reasons, it is not possible to conduct an ex post econometric analysis for evaluating the returns to public investment in agriculture. A different approach has to be applied so that the available data can be used to the greatest extent possible. With help from MINAGRI we have obtained a spending plan with detailed target and costing information, prepared for the second EDPRS. Based on the information received and other data drawn from the literature, we have developed an ex ante approach to organize this information as inputs into the DCGE model. We then use the DCGE model to conduct a series of simulation analyses to assess the returns to public investment in the agricultural sector.

Table 7.6 summarizes the total amount of public investment in agriculture planned for 2007–15, drawn from Rwanda, MINECOFIN (2008). The original assessment of national needs to achieve the EPDRS targets is for a five-year period (2008–12). To be consistent with the first MDG time frame, we decided to consider

Table 7.6—Total accumulated investment, 2007–15

Agricultural spending	Total for 2007–15	Fixed investment	Recurrent investment	Fertilizer and seed subsidies	Annual total average
Agricultural spending used in the model (RWF million)	862,132	484,787	190,502	186,842	95,792
Crops (directly related only)	415,077	182,956	45,278	186,842	46,120
Forestry	8,641	6,742	1,899		960
Livestock	203,253	154,259	48,994		22,584
Research and development, extension	26,963		26,963		2,996
Rural finance	13,662		13,662		1,518
Other investment, horticulture	122,236	90,660	31,576		13,582
Other investment, traditional export	22,840	16,940	5,900		2,538
Rural road	21,965	21,965			2,441
Agricultural institution	16,230		16,230		1,803
Other investment	11,265	11,263			1,252
Annual total agricultural spending, 2007					
Value (RWF million)		13,517	6,434		19,951
Share in total government budget (percent)		1.4	7.4		3.9
Proposed agricultural spending in EDPRS, 2008–12					
Value (RWF million)	242,000	158,000	84,000		48,400
Share in total government budget (percent)	7.0	11.5	4.1		
Increase from the current annual level (multiple factor)					1.4
Amount of agricultural spending to meet CAADP 10 percent total budget target (annual, RWF)					69,143
Compared with the number used in model, without fertilizer subsidy (model/10 percent budget)					1.09
Compared with the number used in model, with fertilizer subsidy (model/10 percent budget)					1.39

Source: Authors' calculations.

Notes: CAADP = Comprehensive Africa Agriculture Development Programme. EDPRS = Economic Development and Poverty Reduction Strategy. RWF = Rwandan francs. Blank cells = not applicable.

a nine-year period (2007–15) for the analysis. Moreover, the initial assessment of the public investment required by the EDPRS targets had to be scaled down because of budget constraints set by the Rwandan Ministry of Finance. The final agreed-on total spending for agriculture is about 30 percent of what had been originally planned (see second part of Table 7.6). However, for this analysis we decided to use the original budget allocation for the following three reasons. First, the purpose of this analysis is to provide an assessment of actual requirements in agricultural investment for achieving both the CAADP growth target and the first MDG goal of halving poverty by 2020. After assessing the growth requirement in the previous chapter of the report, it is necessary to understand the cost of such growth with a complete picture without taking into account the budget constraints. Second, our analysis considers the nine years between 2007 and 2015. Without scaling down the total cost planned by MINAGRI, we can slightly reduce the annual cost by allocating the same amount of total spending over the nine years instead of over five years (annual spending is still about 50 percent higher in our analysis than that included in the EDPRS; see the annual average column of Table 7.6 for comparison). Third, we also consider the CAADP targets, one of which requires African countries to allocate at least 10 percent of government spending to agriculture. The amount of agricultural spending, if it is based on the originally planned numbers of MINAGRI, will allow the agricultural sector to reach 10 percent of total government budget.[1]

The key information about budget allocation and targets to be achieved through such public investment (such as how many hectares of irrigated land or how many metric tons of improved seeds will be developed) is available in the dataset received from MINAGRI. Subsidies for fertilizer and improved seeds are not considered in the government budget allocation but are added as a part of public spending in the above budget allocation. As in many other African countries, the past poor performance of the agricultural sector in Rwanda is partly a consequence of the very limited use of improved seeds and fertilizers. According to Kelly et al. (2001b), average consumption of fertilizer per hectare of cultivated land is less than 4 kilograms (kg) in Rwanda. This value contrasts sharply with Sub-Saharan Africa as a whole (ranging from 9 to 11 kg/ha). The average level of use of improved seed is also low, only about 1.3 percent of total seed applied, a level also below the average for Sub-Saharan Africa (Fowler et al. 2007). With increased world oil prices, fertilizer prices have become unaffordable for the majority of small farmers in Africa. Thus, a partial subsidy on imports of fertilizer is seen as a necessary step to increase the use of fertilizer in crop production.

The above budget allocation information is important for any analysis to assess the economic outcome of public investment allocation; however, such information alone is not enough. To assess the impact of public investment on the growth and

poverty reduction ex ante, it is necessary to link the investment and its targets to the economic activities of the agricultural sector. In our analysis the agricultural sector is composed of 16 crop subsectors, 7 livestock subsectors, and fishery and forestry. It is a big challenge to further allocate the investment into the agricultural subsectors, especially for the crop sectors, so that investment can be directly linked to the economic outcome in the ex ante analysis. To get such detailed information at the agricultural subsector and crop level is beyond the current planning capacity of MINAGRI, and so we have to use other information to do it. Through a broad literature review, information about the current level of crop yields in the country, unit production revenue per hectare of different crops, achievable level of crop yields, and recommended levels of fertilizer and improved seeds to achieve it, and other helpful and available information, are used in the analysis. Based on such information, we further allocate each type of investment into agricultural subsectors. Investment or spending that cannot be allocated to a specific sector (such as spending on agricultural research and development, extension, rural finance, and agricultural institutions) is allocated according to the ratio of total nonspecific spending to total specific spending (such as spending on terracing, irrigation, marshland development, and fertilizer and improved seed subsidies).

Growth in agricultural production at the crop or subsector level is unlikely to result from a single intervention—many interventions have to jointly create the maximum impact. For example, without application of fertilizer and improved seeds, returns to irrigation investment are low. To capture the joint impact of different types of investments, we need to further combine different types of public investment at the agricultural subsector level. To do this, we first assume that if modern inputs are applied, then the level of their application will be consistent with the recommended level to achieve the maximum returns from such interventions. The recommended level of fertilizer is drawn from Fleskens (2007). We further assume that if cropland is irrigated, farmers will first use fertilizer and improved seeds to maximize returns from such combinations. Using these assumptions, we can identify which intervention is a binding constraint for the combination of modern technology (inputs). Tables 7.7a and 7.7b report the share of land allocation corresponding to the types of investment and their current status.[2]

Yields are expected to rise with use of modern inputs. Table 7.8 reports the expected yields assuming different combinations of modern inputs resulting from public investment or spending. A broad literature search for such information was conducted to define the appropriate yield for different types of modern inputs and their combinations. Moreover, the land allocated to different types of investments and their combinations reported in Table 7.7b is consistent with the yields reported in Table 7.8. Such levels of yield are often the results of applying modern inputs at their optimal levels. For example, Table 7.8 shows that the yields obtained by using

Table 7.7a—Current land allocation within sectors by type of investments or spending (percent)

Sector	Modern practices (irrigation, fertilizer, and seed)	Terracing, fertilizer, and seed	Terracing and seed	Terracing only	Marshland development, fertilizer, and seed	Marshland development and seed	Marshland development only	Seed only	Traditional practices
Wheat	0.2	0.1	6.5	0.2				0.4	92.7
Maize	0.2	0.4	6.0	0.2				0.3	92.9
Rice	15.0				4.0	22.7	18.4		40.0
Sorghum	0.1	0.2	6.4	0.1				0.3	93.0
Potatoes	1.0	1.9	0.4	6.5					90.3
Sweet potatoes	0.1	0.0	3.1	1.7					95.1
Cassava	0.1	0.1	3.0	3.3					93.5
Other roots	0.1	0.0	3.1	1.7					95.1
Pulses	0.1	0.2	0.9	0.7					98.1
Vegetables	8.4								91.6
Bananas	0.3	0.1	2.8	0.3					96.5
Other fruits	5.6								94.4
Oilseeds	0.1	0.6	2.8	0.1					96.5
Coffee	29.6								70.4
Green tea	35.3								64.7
Other export crops	8.0				1.4	18.8	38.5		33.3
Total	1.5	0.3	2.6	1.2	0.0	0.3	0.3	0.1	93.7

Source: Authors' calculations based on Rwanda, MINAGRI (2008).
Note: Seed = improved seed application. Blank cells = not applicable.

Table 7.7b—Share of targeted land allocation by type of investments or spending, 2015 (percent)

Sector	Modern practices (irrigation, fertilizer, and seed)	Terracing, fertilizer, and seed	Terracing and seed	Terracing only	Marshland development, fertilizer, and seed	Marshland development and seed	Marshland development only	Traditional practices
Wheat	4.0	2.5	8.5	7.0				78.0
Maize	3.2	3.0	11.2	4.9				77.7
Rice	15.0				23.0	30.0	17.0	15.0
Sorghum	0.5	0.8	12.6	3.3				82.8
Potatoes	2.2	3.5	3.8	13.6				76.9
Sweet potatoes	0.7	0.5	4.6	6.4				87.8
Cassava	0.8	1.4	4.3	9.1				84.5
Other roots	0.3	0.5	5.1	6.0				88.2
Pulses	0.2	0.6	1.3	4.4				93.4
Vegetables	20.2							79.8
Bananas	0.6	2.5	7.3	23.6				66.0
Other fruits	12.4							87.6
Oilseeds	1.5	3.1	6.0	12.0				77.4
Coffee	59.3	40.7						
Green tea	70.6	29.4						
Other export crops	9.6				18.6	40.0	29.2	2.6
Total	4.4	3.0	5.1	9.5	0.5	0.7	0.5	76.3

Source: Authors' calculations based on Rwanda, MINAGRI (2008).
Note: Seed = improved seed application. Blank cells = not applicable.

Table 7.8—Yields for different types of investments or spending (metric tons per hectare)

Sector	Modern practices (irrigation, fertilizer, and seed)	Terracing, fertilizer, and seed	Terracing and seed	Terracing only	Marshland development, fertilizer, and seed	Marshland development and seed	Marshland development only	Traditional practices	Current average	Average yield in baseline, 2015	Targeted average yield, 2015
Wheat	3.0	2.8	1.4	2.3				1.2	0.8	1.2	1.6
Maize	3.5	3.1	1.5	2.5				1.2	0.8	1.0	1.5
Rice	6.4	5.8	5.5	5.8	6.1		6.1	5.5	3.7	4.9	4.7
Sorghum	3.4	2.7	1.7	2.4				1.5	1.1	1.5	1.7
Potatoes	27.2	24.9	15.5	20.2				12.6	9.1	11.9	14.7
Sweet potatoes	15.0	16.8	11.2	11.5				7.7	5.5	6.9	7.8
Cassava	27.3	24.7	11.2	18.8				8.6	6.2	8.0	10.5
Other roots	24.5	17.3	9.6	12.3				6.8	4.9	6.0	6.8
Pulses	2.7	2.4	1.2	2.1				1.1	0.8	1.0	1.0
Vegetables	29.5	19.6	14.0	19.6				14.0	9.4	7.3	9.4
Bananas	17.9	15.7	10.5	14.9				9.9	7.2	10.0	12.9
Other fruits	28.6	19.1	13.6	19.1				13.6	9.7	14.3	17.1
Oilseeds	2.7	1.8	1.1	1.4				0.8	0.6	0.8	1.1
Coffee	1.0	0.8	0.7	0.8				0.7	0.7	1.1	1.1
Green tea	1.7	1.4	1.2	1.4				1.2	1.1	1.7	1.7
Other export crops	45.8	38.2	27.3	38.2	32.7	23.8	32.7	27.3	17.6	26.5	35.0

Source: Authors' calculations based on various literature.

Notes: Yields are weighted by areas with different combinations of inputs and investments. Seed = improved seed application. Blank cells = not applicable.

modern technology will be quite high; for example, maize can reach 3.5 metric tons per hectare (mt/ha) and potatoes 27 mt/ha. Although such yields seem to be at the maximum possible, when they are weighted by the corresponding land allocation reported in Table 7.7b, the effect on the national average yield is quite small, as only about 4.7 percent of total cropland (see the final row of Table 7.7b) is expected to achieve such high levels of yield with the application of modern technology and inputs. Moreover, more than 70 percent of cropland will still be without access to modern inputs by 2015, and yields achieved with traditional technology will still play a dominant role in determining the national average yields for most crops at that time.

As shown in the last column of Table 7.8, yields from most crops will continue to be low in 2015, even after significantly increased public investment in agriculture. For example, the average maize yield at the country level is expected to be only around 1.5 mt/ha by 2015, although it is possible to have a yield of 3.5 mt/ha with a combination of irrigation, fertilizer, and improved seeds (see the first column of Table 7.8). Although it is a significant increase from the current level of maize yield of 0.8 mt/ha, this value is still lower than the maize yields already achieved by many Sub-Saharan African countries. To compare the current level of yield and possible yields by 2015 under the business-as-usual assumption, we report in the last three columns of Table 7.8 three different levels of national average yields. The yield level reported in the "Current average" column of Table 7.8 is consistent with the base-year yields applied in the model. Those numbers in the Table 7.8 column for the average yield in baseline, 2015, are consistent with those in the Table 7.2a column for yield in 2015. The numbers reported in the last column of Table 7.8 can be understood as the targeted average yield by 2015: the expected results with all planned public investment implemented.

Targeted crop average yields and the outcome of public investment in livestock and roads are applied in the DCGE model as exogenous shocks to land productivity (in the case of crop production) or total factor productivity (in the case of livestock production, trade, transportation, and communication sectors). Ideally, the DCGE model should consider all these different types of technologies to endogenously capture the productivity growth at the national level as a result of technology shifting from low to high yields. However, constrained by a lack of such information at the district level and between different types of farm groups (the production functions are defined at the district level for small and medium–large farms in the model), we are unable to capture the endogenous productivity growth in the analysis. Instead, we have to apply the exogenous productivity shocks calculated from the potential growth in the yields as results of public investments and use of modern inputs. With such exogenous shocks, the DCGE model generates a series of results that are in general consistent with the planned public investment and its targets. Because of this consistency, we do not need to report the model results of crop yield again.

We focus on the calculation of dollar-to-dollar returns to public investment in agriculture for this discussion. We measure such returns by increased GDP and AgGDP in real terms (that is, in terms of the base-year prices). To do this, we also consider future returns after 2015 from additional investment occurring in the next nine years. To calculate such future returns, we apply a 10 percent social discount rate and choose a long time period, such that for a given amount of public investment combined with recurrent spending, the returns are eventually discounted to close to zero over the period chosen (for example, 20–30 years). We include spending related to fertilizer and seed subsidies in the recurrent spending, which is also discounted with the same 10 percent social discount rate over the same period. As mentioned earlier, returns to public funds invested in a specific sector should not be measured narrowly by the benefits accrued to this sector. Because they are public goods, public investments often generate strong and positive externalities in the economy, such as technological spillovers in agriculture and growth linkages between agricultural and nonagricultural activities. Thus, increases in GDP over time (discounted to the current value) are used to measure the returns to agricultural investment in Table 7.9, allowing us to fully capture the economywide gains of public investment in agriculture.

It is also important to measure the economywide returns as results of public funds invested in a specific agricultural subsector to understand which sectors yield more efficient returns to investment. For this purpose, we designed a series of model scenarios, each of which focused on the investment going to a specific sector. For example, the first row of Table 7.9 is the result of public funds invested in maize production. In this scenario we assume that productivity growth in maize production is the only direct outcome of increased investment, holding productivity growth in all other sectors at their baseline levels. Similarly, the second row of Table 7.9 assumes that only productivity growth in rice production comes directly from public investment. We also consider the productivity growth for groups of commodities, such as grains or root crops, as the results of public investment. For the "Grains" row, the result is from a scenario in which public investment directly results in the increase of yield in grain production, including maize, rice, wheat, and sorghum, while productivity growth in the other sectors is the same as in the baseline. The last two rows of Table 7.9 display results from the two scenarios considering broad investment in all agricultural subsectors. The second row from the bottom of this table shows that productivity growth in staple crops and livestock is the result of public investment while holding productivity growth in export crops at the baseline level; the last row of the table displays agricultural investments in all subsectors.

The first column of Table 7.9 calculates returns to GDP for each unit of increased public funding invested in the agricultural sector or its subsectors. These returns are equivalent to benefit–cost ratios. The second column of Table 7.9 reports

Table 7.9—Returns to public investment by agricultural subsector: Model results in the investment scenario, 2006–15

	GDP/investment	AgGDP/investment
Grains		
Maize	7.02	6.59
Rice	1.41	1.22
Wheat	5.34	5.15
Roots and tubers		
Cassava	5.46	4.61
Potatoes	5.88	5.66
Sweet potatoes	2.53	2.22
Other staple crops		
Pulses	9.09	8.21
Bananas	5.35	4.94
Oilseeds	5.89	4.73
Export crops		
Coffee	1.01	1.74
Green tea	1.95	2.52
Other cash and export crops	1.08	1.07
Livestock and fishing		
Poultry	10.54	10.09
Other livestock	1.81	1.74
Fishing	12.50	12.35
Grains	2.75	2.73
Root crops	5.03	4.65
Cash and export crops	1.02	1.24
Livestock	2.02	1.90
Staple crops and livestock	3.84	3.63
Agriculture total	3.19	3.11

Sources: Authors' calculations using Rwanda dynamic computable general equilibrium (DCGE) model results combined with the public investment data from Rwanda, MINAGRI (2007).
Note: AgGDP = agricultural gross domestic product. GDP = gross domestic product.

the ratio of increased AgGDP to investment. As shown in the last two rows of this table, economywide returns to public investment in overall agriculture are about 3.1:1.0 and are 3.6:1.0 from investing in staple production (including both staple crops and livestock). The returns to the investment measured as increased GDP are higher than those measured as increased AgGDP for the same amount of public spending in agriculture. These results further indicate the importance of fully measuring the economywide returns of agricultural investment, because such spending also indirectly benefits nonagricultural sectors through production linkages (such as using agricultural materials as inputs to agroprocessing or increased demand for trade and transports after more agricultural products are sent to markets) and con-

sumption linkages (because of farmers' increased demands for nonagricultural goods stemming from their increased incomes).

At the aggregated subsector group level (see the second part of Table 7.9), returns to investment in root crops are highest, measured either as increased GDP or AgGDP. Returns to investment in grain production rank second, and returns to investment in export crops are the lowest but are still greater than one. The first part of Table 7.9 reports economywide returns to investments in each agricultural sector's production. For all agricultural sectors, returns to investment, measured by increased GDP, are greater than the cost of the investment, as all the numbers are greater than one and many are greater than two or three. However, in the case of coffee, returns to investment are the lowest, at 1.00 to 1.01. In contrast, coffee investment is quite profitable when measured directly by increased AgGDP, as RWF1 of investment results in RWF1.74 increase in AgGDP over time. That the increased GDP is significantly less than the increased AgGDP indicates the weak linkage of the coffee sector with the rest of economy. Coffee is grown mainly for export, and coffee processing is dominated by a simple process. Without increasing the value addition of coffee production, the sector is unlikely to create strong linkages and multiplier effects in the economy. Moreover, export-led growth can have certain macroeconomic effects on the real exchange rate. For example, if growth in exports of primary products, including primary processed agricultural products (such as coffee and tea) is too high, it may cause the real exchange rate in the country to rise. An appreciated exchange rate could in turn raise the cost for other exportable sectors and make them more difficult to export. An appreciated exchange rate causes imports to become cheaper and thus import-competitive sectors become unable to compete. This is the other important factor explaining why returns to investment in coffee, measured by increases in GDP, are so low.

Conclusions

Understanding alternative agricultural growth options and their linkages with poverty reduction and prioritizing agricultural investments are the two key components of any agricultural development strategy. However, the relationships between growth and poverty reduction and between targeted growth and required public investment are not straightforward. Solid research is needed to support evidence-based policymaking and strategy formulation. This chapter provides such a study using Rwanda as the case country. The economywide DCGE model discussed in Chapter 2 was applied to the most recent economic data and public investment information to analyze the agricultural growth and investment options for poverty reduction in Rwanda. The analysis focuses on the linkages and trade-offs between growth and poverty reduction goals at the macro-, meso-, and microeconomic levels. It addresses

three policy-related questions: (1) What are the most effective pro-poor agricultural growth options? (2) How can the important linkages between agriculture and nonagriculture be strengthened so that nonfarm activities will become an important source of income for both growth and poverty reduction? (3) What are the most cost-effective public investment choices for stimulating shared growth and poverty reduction? The following key messages can be drawn from its analysis.

Accelerated Agricultural Growth Is Both Necessary and Achievable

Low agricultural productivity and its interaction with environmental sustainability as the most severe challenge to Rwandan agriculture and rural development has been widely recognized both by researchers and the government. Productivity-led growth in agriculture is a key component of the country's development strategy to deal with such challenges, and a series of targets has also been included in the strategy. The DCGE model simulations of this study indicate that the country's targeted agricultural subsector growth, if achieved, would allow Rwanda to meet the CAADP target of 6 percent AgGDP growth from 2008 to 2015. With comparable growth in the nonagricultural sector, the agricultural growth would increase to 6.5 percent and total GDP growth to 7.4 percent, as a result of economywide linkages. The model also analyzes the linkages of this growth with the poverty reduction target of the strategy. Such growth would decrease the national poverty rate to 35.5 percent by 2015, a reduction of 24.8 percentage points over the 1999 rate. If this level of growth were to continue to 2020, Rwanda would be able to achieve the first MDG of halving its national poverty rate by 2020, a target included in the country's *Vision 2020* (MINECOFIN 2000) and EDPRS (MINECOFIN 2008).

The Pattern of Subsector Growth Matters

Agriculture comprises different activities, and export subsectors have often attracted more attention than other subsectors in many African countries' agricultural strategic plans. Stemming from the belief that export-oriented subsectors can contribute more to the agricultural transformation, these subsectors have also disproportionally attracted more public resources and favorable policies. A similar policy bias also exists in Rwanda. Thus, it is necessary to understand the role of different types of agricultural subsectors in both growth and poverty reduction to help prioritize public investment and agricultural policy. The DCGE model discussed in this chapter includes detailed agricultural activities as individual subsectors as well as a broad range of many nonagricultural activities. Through linkages between agriculture and nonagriculture and among agriculture both in production and consumption processes, the DCGE model simulations show that most rural households would benefit from rapid but broad-based agricultural growth and the distribution of such benefits is comparatively equal. However, the most vulnerable households—those with

extremely small landholdings and few opportunities to participate in the production of cash crops—appear to benefit less.

Analyzing the linkages between subsector-level growth and poverty reduction is one of the important contributions of this study, and such an analysis is carried out by endogenously measuring the poverty-reduction response to the economy-wide growth led by different sectors. This chapter first compares the poverty-reduction effect of growth led by the agricultural sector versus that led by the non-agricultural sector, and the model results show that each 1 percent of growth in per capita GDP, driven by agriculture, has a much greater effect on poverty reduction than does the same level of growth driven by the nonagricultural sector. The chapter further compares the subsectors' roles in poverty reduction by simulating economy-wide growth led by different agricultural subsectors. The simulation results indicate that overall growth driven mainly by increased productivity in staple crops has the greatest effect on poverty reduction. Agricultural households with greater opportunities to produce high-value export products are better positioned to benefit from export agriculture. But these households are usually not as poor as other, more remote, households, so export-led growth may have less impact on reducing poverty.

The roles of different agricultural subsectors in economic development are also analyzed from other aspects. Cereals, especially rice and maize, are among the high priorities in the government's strategy document; accordingly, they have high growth targets. If these growth targets are reached, cereals would become the most important source of income growth for many rural households, especially for those with relatively small landholdings. Results of the report also show that food security does not equal food self-sufficiency. Although growth in cereals would help the country reduce its dependence on imports, both maize and rice will continue to depend on imports, but the ratio of imports to domestic consumption will significantly fall by 2015. In contrast, export agriculture is important because of its contribution to macroeconomic balance in trade. High growth in both traditional and non-traditional agricultural exports is targeted in the government's strategy, and the model shows that such growth would significantly increase agricultural trade surpluses. The projected agricultural trade surplus would be about 29 percent of the nonagricultural trade deficit, more than three times the current ratio.

This chapter also warns of possible price declines in some commodities with very high growth targets. Unbalanced growth does not always benefit producers if it is concentrated in a few subsectors. As the targeted growth rates for some livestock products (such as poultry and raw milk) are very high, a negative price effect could result if production growth is out of balance with income growth. Simulations indicate that with an annual growth in poultry production of more than 9 percent and in raw milk more than 15 percent during 2007–15, prices for these two com-

modities will decline 35–40 percent, even though their demand is highly income elastic.

More Agricultural Expenditure and Higher Spending Efficiency Are Needed

Required public investment in agriculture is calculated in this chapter according to the growth needed to meet the CAADP agricultural growth goal of 6 percent or the first MDG by 2020. The efficiency of spending, which is captured by the elasticity of agricultural growth to spending, affects the amount and growth of agricultural spending. This chapter shows that meeting the CAADP growth target will require allocation of public resources to the agricultural sector to rise to 10.0–17.6 percent of total spending by 2015, where the lower value reflects a higher growth–spending elasticity (that is, more efficiency in spending) and the higher value reflects a lower elasticity. These levels of allocation translate, in real terms, to 15 and 30 percent annual growth in agricultural spending. Given that agriculture needs to grow at 6.5 percent to meet the goal of halving the national poverty rate by 2020, more rapid growth in agricultural spending between 2008 and 2015 is required. Our result in terms of required agricultural spending, using the high elasticity that represents an average standard for the Sub-Saharan Africa as whole, is consistent with the CAADP target, which requires a minimum of 10 percent of the government budget to be allocated to agricultural spending. This result is also consistent with the original cost estimation prepared by MINAGRI without scaling down because of the constraints set by the Rwandan Ministry of Finance. Such a spending pattern seems to be necessary both for achieving more than 6 percent agricultural annual growth and for helping the country meet the target set in *Vision 2020* for halving poverty by 2020. Of course, efficiency of public spending must also improve.

Economywide Returns to Public Investment in Agriculture Are High

For an agricultural strategy that can be practically implemented, it is necessary to understand what can be done in addition to what should be done. To help understand the first part of this issue, returns to public investment in agriculture need to be analyzed. Most cost–benefit analyses are at the micro or project level, which may significantly underestimate the returns to public investment, because such investments generally have impacts going beyond the targeted sector or project. One of the important contributions of this chapter is to measure such returns from an economywide perspective. Although the approach used in the measure is ex ante because of a lack of past investment data for a sound econometric estimation, the measurement results are informative for prioritizing public investment. Our analysis finds that, measured as increased GDP over time, the economywide return to agricultural investment (the benefit–cost ratio) is 3.2:1.0. Part of such gains comes from

growth in the nonagricultural sector as a result of multiplier and linkage effects between agriculture and nonagriculture. Comparing increased GDP with increased AgGDP as the outcomes of RWF1 of additional public investment in agricultural staples, we see that increased GDP is RWF0.21 more than that of AgGDP, indicating that returns to agricultural investment stimulates growth in the nonagricultural sector.

The Highest Economywide Returns from Investment Are from Staple Crops

Using an approach similar to that discussed above, our study also measures returns to agricultural investments in different agricultural subsectors. The results show that economywide returns to public investment in staple crop production are the highest of all sectors. Spending on root crops is particularly efficient. Given that both current yields and the use of modern inputs are extremely low for most grain and root crops (except for rice) in Rwanda, even compared to other Sub-Saharan African countries, the country needs to give a much higher priority to these crops than is usual. The high returns are also the result of a linkage effect, particularly for root crops, as productivity growth in such crops lowers pressure on land expansion, which is an extremely important factor that must be taken into consideration in any agricultural strategy for Rwanda. Staple crops are broadly consumed by poor consumers in both rural and urban areas, and reduced food prices from productivity-led growth benefit the poor consumers and create more growth opportunities in other agricultural and nonagricultural sectors. However, the amount of investment specified in EDPRS (Rwanda, MINECOFIN 2008) will not be enough to significantly improve the low yields of many crops nationwide. The average yield for maize will be as low as 1.5 mt/ha even in 2015, a level many African countries have already reached.

Trade-Offs Exist between Exports and Overall Growth When Investing in Export Crops

Although investment in export crops has the highest impact on growth in these subsectors, the economywide returns are quite low. The growth rate of coffee and tea can reach double digits with targeted investment to the export sector, measured by increased GDP over time; however, such investment has the lowest returns of all sectors, particularly in the case of coffee. The reason for these low returns is mainly due to the weak linkages with other economic activities both on the production and consumption sides. It is possible to strengthen such linkage effects in the export sector by promoting agroprocessing with high-value addition (because of weak income–consumption linkages), but the same amount of public investment in the export sector is not likely to become a dominant driver for both overall economic growth and poverty reduction.

In many African countries the export sector has often attracted more government attention than have other sectors. With favorable policies and investment support, government spending to promote the export sector represents a much higher share of total agricultural spending, compared to the size of the export sector in the total agricultural economy. The findings of this chapter show relatively low economywide returns to public spending in the export sector and relatively less poverty reduction from growth led by promoting exports, further indicating the importance of broad-based agricultural growth. Agricultural development strategy, including an effective public investment strategy, should focus more on growth in which a majority of farmers can participate. Only such a strategy can be expected to be efficient and effective in growth and poverty reduction, as well as in the economic development of the country in general.

How Relevant Is the Rwandan Case to Other African Countries?

Although Rwanda is one of the smallest countries and has the highest population density in Africa, similarities do exist between Rwanda and many other African countries. First, it is true that at the country level, fewer African countries have such high population pressure in economic development as in Rwanda. Constrained by the lack of additional arable land to support high population growth, to develop an efficient agricultural system whose growth is productivity driven and sustainable environmentally is more urgent in Rwanda than in other African countries. However, because of recent rapid increases in population throughout the continent, many countries have started to feel similar pressure from population growth on agricultural development either at the country or subnational level. Such countries as Ethiopia, Kenya, and Malawi face similar constraints in their high-population areas, and such areas are often the food baskets of their respective countries. Environment degradation (such as soil erosion and deforestation stemming from extensive farming systems) is commonly observed in certain areas of almost all African countries, even in the countries with relatively abundant land, such as Ghana and Nigeria. Thus, challenges facing Rwanda's agriculture today are becoming challenges facing agricultural development in many other African countries today or in the near future. From this point of view, the analysis discussed in this chapter is highly relevant to many African countries in terms of their agricultural development strategies.

Second, agriculture is once again becoming a top priority on the agenda in economic development strategy for all African countries. As a result, an understanding of the linkages in growth across agricultural subsectors and between agriculture and nonagriculture and the linkages between growth and poverty reduction is commonly required for designing an agricultural strategy. Although such understanding has to be country specific, the methodology developed in this chapter, which takes

an economywide perspective, is useful for many countries. The general principles that this chapter emphasizes—such as to link agricultural subsectors' targets to overall growth and poverty reduction, to understand the different roles of different subsectors in growth and poverty reduction at the macro- and microlevels, and to pay attention to certain trade-offs and negative effects (such as price effects) of rapid and unbalanced growth—are all relevant to other countries when designing their development strategies.

Third, almost all African countries are facing constraints on their public resources for supporting agricultural growth. The financial gap between what should be done and what can been done is commonly seen in many country's development strategy documents. By calculating the public spending required for achieving the targets set by the strategy documents, this chapter explicitly measures such gaps and points out that their acknowledgment has to be a part of any development strategy. The chapter emphasizes the relationship between the efficiency in spending and the amount of spending required to support agriculture, which is a common challenge facing many African countries. As in Rwanda, a commonly observed constraint in many African countries is that, because of a lack of sufficient data and information for a reasonable econometric analysis, the returns to public investment are unlikely to be measured at the sector level to better prioritize public investment. This chapter describes a new approach (though it is ex ante) that is able to fully use the information available in a country's PRSP preparation process. This approach can be adopted in other countries' strategic studies.

Finally, research on development strategy at the country level in Africa is a new field in today's political environment. As more and more countries define their agricultural development strategies and almost all these strategies are dynamic documents to be improved and updated over time, the needs for evidence-based development-strategy research are high and demand is rising. However, researchers in this field are facing challenges stemming from a lack of solid data and feel the urgency to provide research outcomes in a relative short period of time to meet policy demand. Although the analysis presented in this chapter is far from perfect, it is an encouraging attempt to make development research more relevant to developing countries' policies and strategies.

Appendix

Table 7A.1—Structure of the Rwandan social accounting matrix

Agricultural sectors	Wheat; maize; rice; sorghum; potatoes; sweet potatoes; cassava; other roots; pulses; vegetables; bananas; other fruits; oilseeds; export crops; coffee; tea; other export crops; cattle; sheep and goats; swine; poultry; raw milk; eggs; other livestock products; forestry; fishing
Industrial sectors	Mining; meat, fish, and dairy products; processed cereals; processed coffee; processed tea; bakery and processed sugar; traditional beverages; modern beverages; tobacco; textiles and clothing; wood, paper, and printing; chemicals; nonmetallic minerals; furniture and other manufactured products; electricity, gas, and water; construction
Service sectors	Wholesale and retail trade; hotels and restaurants; transport; communications; finance and insurance; real estate; business services; repair; public administration; education; health; other personal services
Factors	Unskilled agricultural labor; unskilled nonagricultural labor; skilled labor; agricultural land (by regions); agricultural capital; nonagricultural capital
Households	Farm households by region (60 in total); nonfarm households (2 in total)
Regions	Administrative districts for agriculture only (30 districts in total further disaggregated into small farms and medium–large farms)

Source: Authors.

Notes

1. Seven percent of total planned public spending between 2008 and 2012 will be allocated to agriculture in EDPRS.

2. According to Kelly et al. (2001b), 5 percent of farmers used inorganic fertilizers or lime (or both) on 3 percent of cultivated land during the 2000 season. However, as we assume that fertilizer is used at the recommended level, the number reported in Tables 7.7a and 7.7b for fertilized land as a share of cultivated land is smaller than what was reported by Kelly et al.

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