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Agricultural Growth and Investment Options for Poverty Reduction in Rwanda

Xinshen Diao
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Sam Kanyarukiga
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agriculture, GDP, poverty, public investment, MDG

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ABSTRACT

An economywide, multimarket (EMM) model was developed for Rwanda to analyze the linkages and trade-offs between growth and poverty reduction goals at both macro- and micro-economic levels. The model includes 30 agricultural commodities or commodity groups from eight broad agricultural subsectors, along with two aggregated nonagricultural sectors.

The analysis compares the economic, income, and poverty effects of a variety of growth scenarios based on existing national subsector growth targets. The analysis shows 6 percent of CAADP's agricultural GDP growth target is achievable if growth reaches its target at the agricultural subsectoral level. But it is not enough for the country to achieve the MDG One, although the national poverty rate in 2015 will be 17 percent lower than that in 2005. Moreover, the household groups with the smallest landholding size, female-headed, or with few opportunities to participate cash crop production seem to benefit less from such growth. The study also examines the different growth-poverty linkages at agricultural subsector level, and shows that growth driven by productivity increases in staple crops and livestock production can reduce the poverty more than in the case where growth is driven by export crops or by the nonagricultural sector.

The analysis also shows that to achieve growth required by CAADP and MDG One, the country needs to substantially beef up its public investment in agriculture. The share of agricultural spending in total government spending is required to increase from the current level of 5 percent to 10-35 percent in 2015.

AGRICULTURAL GROWTH AND INVESTMENT OPTIONS FOR POVERTY REDUCTION IN RWANDA

Xinshen Diao, Shenggen Fan, Sam Kanyarukiga, and Bingxin Yu [1]

I. INTRODUCTION

Rwanda has made a remarkable transition from the genocide of the mid-1990s to macroeconomic stabilization by 1998 (IMF 2004), and to peace and burgeoning development today, as the country achieved one of the highest growth rates in Africa for the last 10 years. The Government of Rwanda is committed to further stimulating growth and significantly reducing poverty (Government of Rwanda 2003; MINECOFIN 2002a). Agricultural development is considered a key pillar in these efforts, as well as efforts to achieve other development objectives, such as the international community's Millennium Development Goals (MDGs). In association with the New Partnership for Africa's Development (NEPAD), the Government of Rwanda is in the process of implementing the Comprehensive Africa Agricultural Development Program (CAADP); hence, a series of growth targets have been established for individual agricultural subsectors.

Since there are choices involved within the agricultural sector, both for the sector as a whole and across subsectors in the overall economic development, many investment and policy interventions will be designed at the subsector level. However, strong interlinkages occur across subsectors and between agriculture and the rest of the economy. To understand such linkages and how sectoral growth will contribute to the country's broad development goals, an integrated framework is needed in order to synergize the growth projections among different agricultural commodities or subsectors and evaluate their combined effects on economic growth and poverty reduction. Moreover, agricultural production growth is often constrained by demand in both domestic and export markets, and demand, in turn, depends on income growth both in agriculture and in the broader economy. While agriculture is a dominant economic

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activity in Rwanda (the majority of population is in the rural), both rural and urban sectors need to be included in this framework in order to understand the economywide impact of agricultural growth.

The objective of this study is to analyze agricultural growth and investment options in order to support the development of a comprehensive rural development component under Rwanda's Economic Development and Poverty Reduction Strategy (EDPRS), in alignment with principles and objectives collectively defined by African countries as part of the broader NEPAD agenda. In particular, the study seeks to position Rwanda's agricultural and rural sectors within EDPRS. For this purpose—and, in particular, to assist policymakers and other stakeholders to make informed, long-term decisions—an economywide, multimarket (EMM) model for Rwanda has been developed and used to analyze the linkages and trade-offs between economic growth and poverty reduction at both macro- and micro-economic levels. It is expected that the model will be a valuable policy analysis tool for the prioritization of economic reform and investment to maximize the positive effects of economic growth on poverty reduction.

In addition, the study attempts to quantify the required public resources in the agriculture sector in achieving these different development goals committed by the government. Although this is only an early attempt given the availability of data, it provides important information on public resources required to achieve these goals and for setting future investment priorities.

II. ANALYTIC TOOLS AND DATA

The EMM and Micro-Simulation Models

The economywide, multimarket (EMM) model is a tool designed to capture economic interlinkages in Rwanda in an integrated framework that enables the synergies and trade-offs inherent in different agricultural growth options. While the official data show that agriculture accounts for 40 percent of total gross domestic product (GDP) in Rwanda (MINECOFIN 1999), 90 percent of population lives in rural areas, where poverty predominates (MINECOFIN 2002b). Thus, the EMM model has an agricultural focus. It includes 30 agricultural commodities or commodity groups from eight broad agricultural subsectors: grains (maize, rice, wheat, and sorghum); bananas; roots and tubers (cassava, potatoes, sweet potatoes, and other root crops); pulses and oilseeds (beans, peas, soybeans, and peanuts); export crops (coffee, tea, and pyrethrum); other cash crops (sugar, fruits, and vegetables); livestock and products (beef, goat and sheep meats, poultry, other meat, fish, eggs, and milk), and other agricultural food (vegetable oils, beverages, and other home processed food) and nonfood (hides and skins) commodities. The model also includes two aggregated nonagricultural sectors (manufacturing and services) (Table 1).

The EMM model also considers regional heterogeneity, so production and consumption of all the commodities/sectors are spatially disaggregated into 11 provinces and the city of Ville de Kigali. With the highest rural population density in Africa, Rwanda is a land-scarce country with a majority of farmers as smallholders, and the size of landholdings is highly correlated with rural poverty (MINECOFIN 2002b). Thus, the model further disaggregates rural households in each of the 11 provinces into three groups according to the size of landholdings. Specifically, Rural Group 1 represents rural households with landholdings less than 0.3 hectare, including rural landless households; Rural Group 2 includes households with landholdings between 0.3 and 1.0 hectare, and Rural Group 3 includes households with more than 1 hectare of land. (See Table 2 for the distribution of households across the three groups.)

Table 1. Agricultural Commodities and Nonagricultural Sectors in the EMM Model

Commodity	Initial Trade Assumption	Simulated Growth
Grains		
Maize	Imports	✓
Rice	Imports	✓
Sorghum	Balanced domestic market	
Wheat	Imports	✓
Bananas	Balanced domestic market	
Roots and tubers		
Cassava	Balanced domestic market	✓
Potatoes	Balanced domestic market	✓
Sweet potatoes	Balanced domestic market	
Other root crops	Balanced domestic market	
Pulses and oilseeds		
Beans	Imports	
Peas	Imports	
Peanuts	Balanced domestic market	
Soybeans	Balanced domestic market	✓
Export crops		
Coffee	Exports	✓
Tea	Exports	✓
Pyrethrum	Exports	✓
Other crops		
Vegetables	Balanced domestic market	
Fruits	Balanced domestic market	
Sugar	Imports	
Livestock products		
Beef	Balanced domestic market	✓
Goat and sheep meats	Balanced domestic market	✓
Poultry	Balanced domestic market	✓
Other meat	Balanced domestic market	✓
Fish	Balanced domestic market	✓
Eggs	Balanced domestic market	✓
Milk	Imports	✓
Other food		
Vegetable oil	Imports	
Beverages	Balanced domestic market	
Home-processed food products	Balanced domestic market	
Nonfood		
Hides and skins	Exports	✓
Industrial goods	Imports	
Services	Balanced domestic market	

Table 2. Household Groups in the Model

Province	Rural Group 1 Per household landholding of less than 0.3 hectare		Rural Group 2 Per household landholding of 0.3 to 1.0 hectare		Rural Group 3 Per household landholding of more than 1.0 hectare		Urban		Rural total	Total
	Female-headed	Male-headed	Female-headed	Male-headed	Female-headed	Male-headed	Female-headed	Male-headed		
Number of households										
Butare	33,052	61,219	10,093	17,046	3,731	8,810	3,574	3,546	133,951	141,071
Byumba	13,594	38,308	11,693	42,779	9,353	34,298	619	1,830	150,025	152,474
Cyangugu	19,195	44,223	8,307	15,782	4,076	18,077	796	2,055	109,660	112,511
Gikongoro	21,222	44,610	2,263	12,437	3,693	15,483	683	1,500	99,708	101,891
Gisenyi	18,413	37,028	17,322	31,673	12,344	29,424	837	5,348	146,204	152,389
Gitarama	27,420	30,068	20,230	40,477	16,745	30,777	1,504	3,764	165,717	170,985
Kibungo	4,959	6,939	16,848	39,099	15,737	45,209	2,282	2,250	128,791	133,323
Kibuye	16,721	27,048	10,002	20,907	6,122	12,577	292	2,640	93,377	96,309
Kigali	17,889	25,656	26,875	45,185	24,870	40,825	1,539	4,257	181,300	187,096
Ruhengeri	30,280	63,452	20,132	40,050	7,773	19,342	1,746	4,414	181,029	187,189
Umutara	3,730	4,533	9,874	16,302	7,604	19,243	305	610	61,286	62,201
City Kigali	—	—	—	—	—	—	30,362	82,349	0	112,711
National	206,475	383,084	153,639	321,737	112,048	274,065	14,177	32,214	1,451,048	1,497,439
Percentage of national rural total										
Butare	2 3	4 2	0 7	1 2	0 3	0 6	—	—	9 2	—
Byumba	0 9	2 6	0 8	2 9	0 6	2 4	—	—	10 3	—
Cyangugu	1 3	3 0	0 6	1 1	0 3	1 2	—	—	7 6	—
Gikongoro	1 5	3 1	0 2	0 9	0 3	1 1	—	—	6 9	—
Gisenyi	1 3	2 6	1 2	2 2	0 9	2 0	—	—	10 1	—
Gitarama	1 9	2 1	1 4	2 8	1 2	2 1	—	—	11 4	—
Kibungo	0 3	0 5	1 2	2 7	1 1	3 1	—	—	8 9	—
Kibuye	1 2	1 9	0 7	1 4	0 4	0 9	—	—	6 4	—
Kigali	1 2	1 8	1 9	3 1	1 7	2 8	—	—	12 5	—
Ruhengeri	2 1	4 4	1 4	2 8	0 5	1 3	—	—	12 5	—
Umutara	0 3	0 3	0 7	1 1	0 5	1 3	—	—	4 2	—
National	14 2	26 4	10 6	22 2	7 7	18 9	—	—	100 0	—
Percentage of national household total										
Butare	2 2	4 1	0 7	1 1	0 2	0 6	0 2	0 2	—	9 4
Byumba	0 9	2 6	0 8	2 9	0 6	2 3	0 0	0 1	—	10 2
Cyangugu	1 3	3 0	0 6	1 1	0 3	1 2	0 1	0 1	—	7 5
Gikongoro	1 4	3 0	0 2	0 8	0 2	1 0	0 0	0 1	—	6 8
Gisenyi	1 2	2 5	1 2	2 1	0 8	2 0	0 1	0 4	—	10 2
Gitarama	1 8	2 0	1 4	2 7	1 1	2 1	0 1	0 3	—	11 4
Kibungo	0 3	0 5	1 1	2 6	1 1	3 0	0 2	0 2	—	8 9
Kibuye	1 1	1 8	0 7	1 4	0 4	0 8	0 0	0 2	—	6 4
Kigali	1 2	1 7	1 8	3 0	1 7	2 7	0 1	0 3	—	12 5
Ruhengeri	2 0	4 2	1 3	2 7	0 5	1 3	0 1	0 3	—	12 5
Umutara	0 2	0 3	0 7	1 1	0 5	1 3	0 0	0 0	—	4 2
City Kigali	—	—	—	—	—	—	2 0	5 5	—	7 5
National	13 8	25 6	10 3	21 5	7 5	18 3	0 9	2 2	—	100 0

Source Calculated by authors from 1999-2001 EICV.

According to the 1999–2001 Enquete Integrale Sur les Conditions de view des Menages au Rwanda (EICV, or Household Living Conditions Survey in English) (MINECOFIN 2003), about 40.6 percent of rural households belong to Rural Group 1, 32.8 percent to Rural Group 2, and 26.6 percent to Rural Group 3. Gender inequality is common in Rwanda (World Bank 2002). To capture gender heterogeneity in the linkages of growth and poverty reduction, production and consumption data are further disaggregated by type of households, that is, rural female-headed, rural male-headed, urban female-headed, and urban male-headed households. Thus, for each province, there are eight household groups (two urban and six rural), and all households groups are assigned to different supply and demand functions for each individual commodity. In all, there are 3,072 production and demand functions in the model (32 sectors multiplied by 12 provinces multiplied by 8 household groups). Table 2 lists data on the number of households by province, rural/urban area, size of landholding, and gender of household head.

The supply functions in the EMM model have two components for crop production: (a) yield functions used to capture the supply response to own prices based on the farm area allocated to the particular crop; and (b) land allocation functions, which are functions of all prices and, hence, are responsive to changing profitability across different crops based on total available land. The own-price elasticities employed in the yield functions are mainly drawn from other studies, while the cross-price elasticities in the area functions are calibrated according to each household group's share of provincial production for each commodity. The price elasticities in the area functions are calculated using the homogeneity condition, which requires total land area to be fixed in a given year. This incorporates the size of landholdings as a constraint in crop production.

The income elasticity in the demand function for each individual commodity is econometrically estimated using data from the 1999–2001 EICV. Subsistence-level consumption is calibrated to the households' home consumption from the same data set (by household group), while the price elasticities in the demand function are calibrated using the homogeneity assumption imposed on the demand functions. Both income and

price elasticities for any specific commodity vary across household groups due to different consumption patterns at different income levels. Such differences imply that the aggregate effect of consumers' market responses is often nonlinear and much more complex than a national-level definition would indicate; they also indicate a possible differential effect on poverty reduction even with similar national-level income increases.

The national poverty line is determined based on the 1999–2001 Household Living Condition Survey. This is used as a baseline for analyzing growth–poverty effects and estimating targets for reaching MDG 1. A micro-simulation model was also constructed using the 1999–2001 EICV dataset and linked to the EMM model in order to capture micro-linkages between income growth and poverty reduction. As income is an endogenous variable and its growth rate varies across provinces, rural and urban areas, and household groups, income distribution changes over time, as does the population living below the poverty line.

Data

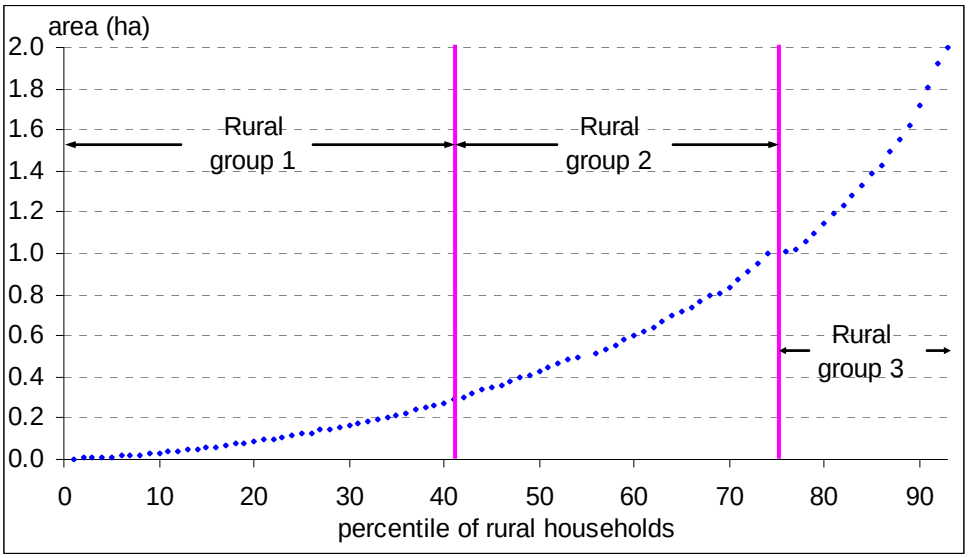
Data used to calibrate the base year of the model are drawn from various sources. Specifically, provincial-level data on agricultural production by crop (including crop output and areas) and livestock product are from the Ministry of Agriculture, Animal Resources and Forestry (MINAGRI 2006). When data for certain crops were unavailable in MINAGRI, Food and Agriculture Organization of the United Nations (FAO) data were used (FAO 2006). Import and export data were taken from a variety of in-country and FAO sources. National level total consumption data, including food and feed consumption and input uses for agricultural processing sector, were calculated from production, subtracting exports and plus imports. Price data were taken from the 1999–2001 EICV and vary across provinces, even for the same commodity. National nonagricultural-sector data were taken from the 2006 World Development Indicators (World Bank 2006), and aggregated GDP for manufacturing and services is used. Production and consumption data for the nonagricultural sectors are disaggregated by household group based on data in the 1999–2001 EICV.

Land and Crop Distribution across Rural Groups

To provide the necessary economic background, it is important to define primary economic characteristics in the data representing the current conditions and economic structure of Rwanda. This first involves land and crop distribution across rural groups. Based on the 1999–2001 EICV and MINAGRI data, respectively, total landholdings in Rwanda are calculated at 1.1 million hectares, while total harvested area is close to 1.7 million hectares. This indicates a ratio of harvested areas to landholdings, known as a multiple cropping index (MCI), of 1.5 for the country as a whole. Given its limited land resources, increasing the cropping index is an important factor in increasing total production. This can best be achieved by investing in irrigation or developing crop varieties with short growth periods.

The distribution of landholdings among rural households is presented by percentile in Figure 1. All rural households included in the 1999–2001 EICV were aggregated into 100 small groups (including sample weights), which were then ranked by average size of landholding, from small (including zero) to large-scale (shown on the x axis). The average size of landholding for each household percentile is shown on the y axis. It is clear that the majority of rural households in Rwanda hold extremely small

Figure 1. Landholding Distribution, by Rural Household Percentile



Source: Calculated by authors from the 1999–2001 EICV.

pieces of land for farming. More than 70 percent of rural households, for example, hold less than 1 hectare, and more than 20 percent less than 0.1 hectare.

Analyzing the three rural groups defined in the model based on size of landholding, about 26 percent of rural households fall into Rural Group 3 (having landholdings of more than 1 hectare). This means that 26 percent of all households hold almost 70 percent of the country's agricultural land. In contrast, Rural Group 1—defined as households with less than 0.3 hectare of land—comprises more than 40 percent of all rural households but holds less than 6 percent of the country's agricultural land. On average, each household in Rural Group 1 holds 0.11 hectare, and about 60 percent of households hold land less than this average. An average household in Rural Group 3 holds 1.94 hectares (Table 3). Given that rural income sources are predominantly derived from agriculture in Rwanda, these extremely small landholdings indicate extremely low incomes and high poverty. Tables 4 through 6 provide data on the distribution of poverty according to the household groups defined in this study. Table 4 shows the number of households below the national poverty line, Table 5 shows the poverty rate across household groups, and Table 6 shows the poverty distribution across regions and household groups, with national total poverty population (rural and urban) being 100. A headcount ratio of 74 percent for Rural Group 1 is significantly higher than the rural average of 66 percent, and almost 20 percentage points higher than the poverty rate for the Rural Group 3, of 54 percent. Moreover, within each rural group, the incidence of poverty is significantly higher among female-headed households. For example, the poverty rate for the female-headed households with landholdings of less than 0.3 hectare (Rural Group 1) is 77.6 percent, while the comparable rate for male-headed households in the same rural group is 72.4 percent.

Table 3. Land Distribution by Household Groups

Indicator	Rural Group 1 Per household landholding of less than 0.3 hectare	Rural Group 2 Per household landholding of 0.3 to 1.0 hectare	Rural Group 3 Per household landholding of more than 1.0 hectare	Rural total
Household share of national total (%)	39.4	31.7	25.8	96.9
Household size (persons)	4.5	4.9	5.6	5.3
Total landholding (ha)	63,921	273,724	749,643	1,087,288
Household share of total rural landholding (%)	5.9	25.2	68.9	100
Average landholding per household (ha)	0.11	0.58	1.94	0.75
Average landholding per capita (ha)	0.02	0.12	0.35	0.15

Source: Calculated by authors from the 1999–2001 EICV.

Table 4. Regional Distribution of Numbers of Households under the Poverty Line

Province	Rural Group 1 Per household landholding of less than 0.3 hectare			Rural Group 2 Per household landholding of0.3 to 1.0 hectare			Rural Group 3 Per household landholding of more than 1.0 hectare			Urban			Regional rural total	*Regional* total
	Female-headed	Male-headed	All	Female-headed	Male-headed	All	Female-headed	Male-headed	All	Female-headed	Male-headed	All		
Butare	24,378	44,744	69,122	7,722	10,693	18,415	880	4,423	5,303	1,100	480	1,580	180,377	187,260
Byumba	12,200	22,913	35,113	7,898	25,370	33,268	4,763	14,877	19,640	0	682	682	156,402	176,724
Cyangugu	11,983	29,418	41,401	6,923	9,386	16,309	2,336	8,135	10,471	254	534	788	125,891	137,150
Gikongoro	17,141	34,185	51,326	1,650	9,332	10,982	2,571	10,363	12,934	296	341	637	137,550	151,121
Gisenyi	12,554	22,042	34,596	12,516	15,862	28,378	6,677	10,729	17,406	312	632	944	143,354	161,704
Gitarama	17,749	14,458	32,207	13,299	18,646	31,945	7,992	10,184	18,176	1,105	564	1,669	146,480	166,325
Kibungo	2,725	3,523	6,248	8,783	18,907	27,690	7,861	15,620	23,481	693	401	1,094	91,357	115,932
Kibuye	12,176	18,330	30,506	6,722	16,253	22,975	4,266	7,647	11,913	0	452	452	118,875	131,240
Kigali	13,455	17,218	30,673	18,523	32,029	50,552	17,836	23,114	40,950	70	0	70	203,400	244,420
City Kigali	—	—	—	—	—	—	—	—	—	5,127	4,760	9,887	—	9,887
Ruhengeri	22,716	47,539	70,255	15,345	25,521	40,866	4,150	12,309	16,459	956	1,239	2,195	238,701	257,355
Umutara	2,301	1,998	4,299	5,429	7,313	12,742	4,172	7,445	11,617	—	—	0	57,316	57,316
National total	149,378	256,368	405,746	104,810	189,312	294,122	63,504	124,846	188,350	9,913	10,085	19,998	1,542,387	1,739,118

Source: Calculated by authors from the 1999–2001 EICV.

Table 5. Poverty Rate by Household Group and Region

Province	Rural Group 1 Per household landholding of less than 0.3 hectare			Rural Group 2 Per household landholding of 0.3 to 1.0 hectare			Rural Group 3 Per household landholding of more than 1.0 hectare			Urban			Regional rural total	Regional Total
	Female-headed	Male-headed	All	Female-headed	Male-headed	All	Female-headed	Male-headed	All	Female-headed	Male-headed	All		
Butare	76.9	77.0	76.9	79.9	69.6	72.8	32.8	57.8	51.2	32.1	12.9	21.7	73.3	70.5
Byumba	91.9	61.7	68.4	77.0	63.6	66.0	52.6	50.9	51.2	0.0	47.6	36.1	61.8	61.3
Cyangugu	71.3	71.7	71.6	82.5	64.9	69.9	57.0	51.2	51.9	32.1	25.7	27.5	66.6	65.5
Gikongoro	84.8	80.3	81.6	64.7	78.5	76.6	80.2	69.5	71.0	30.5	25.6	27.0	78.4	77.4
Gisenyi	68.7	67.7	68.0	79.2	57.6	64.7	59.4	42.9	47.1	29.3	15.7	17.5	60.3	58.0
Gitarama	71.7	56.1	62.4	72.0	52.4	57.6	51.8	39.0	43.1	69.0	17.4	30.7	54.4	53.7
Kibungo	59.2	55.3	57.0	62.0	53.7	55.8	55.3	41.0	44.3	36.9	14.3	25.2	50.1	49.2
Kibuye	79.7	71.6	74.4	72.9	81.2	78.9	77.0	67.5	69.6	0.0	29.7	26.2	74.9	73.8
Kigali	80.5	76.0	77.7	77.1	75.7	76.1	76.2	64.7	68.6	4.6	0.0	1.2	73.4	71.1
City Kigali	—	—	—	—	—	—	—	—	—	17.0	8.0	10.4	0.0	10.4
Ruhengeri	83.5	81.9	82.3	87.8	65.8	71.8	52.3	63.4	60.8	56.3	29.6	35.8	74.8	73.4
Umutara	77.9	49.6	61.4	58.7	51.5	53.8	57.1	43.1	46.8	0.0	0.0	0.0	51.0	50.3
National total	77.6	72.4	74.0	75.4	64.1	67.2	60.5	51.8	53.9	21.9	11.2	14.0	65.7	60.3

Source: Calculated by authors from the 1999–2001 EICV.

Table 6. Distribution of Poverty Population by Household Group and Province

Province	Rural Group 1 Per household landholding of less than 0.3 hectare			Rural Group 2 Per household landholding of 0.3 to 1.0 hectare			Rural Group 3 Per household landholding of more than 1.0 hectare			Urban			Regional rural total	Regional total
	Female-headed	Male-headed	All	Female-headed	Male-headed	All	Female-headed	Male-headed	All	Female-headed	Male-headed	All		
Butare	2.0	4.8	6.8	0.7	1.3	2.0	0.1	0.6	0.7	0.1	0.1	0.2	9.5	9.6
Byumba	1.0	2.3	3.2	0.8	2.9	3.7	0.5	2.2	2.7	0.0	0.1	0.1	9.6	9.7
Cyangugu	1.2	3.6	4.7	0.6	1.3	1.9	0.2	1.3	1.5	0.0	0.1	0.1	8.1	8.2
Gikongoro	1.5	3.7	5.2	0.1	1.1	1.2	0.2	1.4	1.6	0.0	0.0	0.1	8.0	8.1
Gisenyi	1.1	2.5	3.6	1.3	1.9	3.2	0.7	1.5	2.3	0.0	0.1	0.1	9.1	9.2
Gitarama	1.5	1.7	3.3	1.2	2.3	3.5	0.9	1.4	2.3	0.1	0.1	0.2	9.1	9.3
Kibungo	0.3	0.4	0.7	0.8	2.1	3.0	0.9	2.1	3.0	0.1	0.0	0.1	6.6	6.7
Kibuye	1.1	1.9	3.0	0.6	1.9	2.6	0.4	1.1	1.5	0.0	0.1	0.1	7.0	7.0
Kigali	1.1	1.7	2.8	1.8	3.8	5.5	1.9	3.1	5.1	0.0	0.0	0.0	13.4	13.4
City Kigali	—	—	—	—	—	—	—	—	—	0.5	0.7	1.3	—	1.3
Ruhengeri	2.0	5.3	7.3	1.5	3.0	4.6	0.4	1.6	2.0	0.1	0.2	0.3	13.9	14.1
Umutara	0.2	0.2	0.4	0.5	0.9	1.3	0.5	1.0	1.5	0.0	0.0	0.0	3.3	3.3
Total	13.0	28.0	40.9	10.0	22.6	32.5	6.8	17.3	24.1	1.0	1.4	2.4	97.6	100.0

Source: Calculated by authors from the 1999–2001 EICV.
Note: The national total equals 100.

Small landholdings force farmers to allocate most of their land to food crop production to meet the family's basic needs. As shown in Table 7, more than 17 percent of national grains and 13 percent of bananas, root crops, and pulses and oilseeds are produced by Rural Group 1, which holds less than 6 percent of the country's total farmland. Even though these households allocate more land to staple crop production, per capita food availability is still extremely low among these households. The per capita grain production for Rural Group 3, at 75 kilograms, is almost four times the level of households in Rural Group 1, which is only 19 kilograms. A similar situation exists for other staple crops, such that, on average, per capita food availability for Rural Group 1 is 50–70 percent below the national average and 75–85 percent below the per capita level in Rural Group 3.

Table 7. Crop Distribution by Household Group

Indicator	Rural Group 1	Rural Group 2	Rural Group 3	Rural Total
Total production (thousand metric tons)				
Grains	50	81	160	291
Roots and tubers	483	887	1,716	3,086
Bananas	236	712	1,377	2,324
Pulses and oilseeds	38	80	165	283
Share in rural total (percent)				
Grains	17.1	27.9	55.0	100
Roots and tubers	15.7	28.8	55.6	100
Bananas	13.6	28.2	58.3	100
Pulses and oilseeds	13.6	28.2	58.3	100
Average per capita production (kilogram)				
Grains	19	35	75	41
Roots and tubers	183	384	804	455
Bananas	89	308	645	308
Pulses and oilseeds	15	34	77	40

Source: Calculated by authors from the 1999–2001 EICV.

Lack of land constrains rural households from participating in high-value agricultural production. Among the 5,300 rural households covered by the survey, only 61 rural households reported the production of tea and 537 reported the production of coffee—and this may be significantly underreported based on national estimates from

other sources.[2] Based on such data, and taking into account for the sample weights, nationwide, about 1 percent of rural households are directly involved in the production of tea, while 10 percent are directly involved in the production of coffee. Among the tea growers, 22 percent fall under Rural Group 1, and 42 percent fall under Rural Group 3 (despite the fact that Rural Group 1 includes more than 40 percent of all rural households and Rural Group 3 comprises only 25 percent (Table 8). While the numbers of coffee growers are more equally distributed across the three rural groups, the share of households producing coffee is still higher in Rural Group 3 (12 percent) than that in the other two groups (about 9 percent).

Table 8. Distribution of Households Growing Coffee and Tea by Household Groups

Households/commodity	Rural Group 1	Rural Group 2	Rural Group 3	Rural total
Number of rural households				
Coffee	53,171	45,701	48,766	147,638
Tea	2,789	4,790	5,415	12,993
Share of households in rural total (%)	4.53	4.90	5.55	5.25
Coffee	36.0	31.0	33.0	100
Tea	21.5	36.9	41.7	100

Source: Calculated by authors from the 1999–2001 EICV.

Dynamics in Household Demand

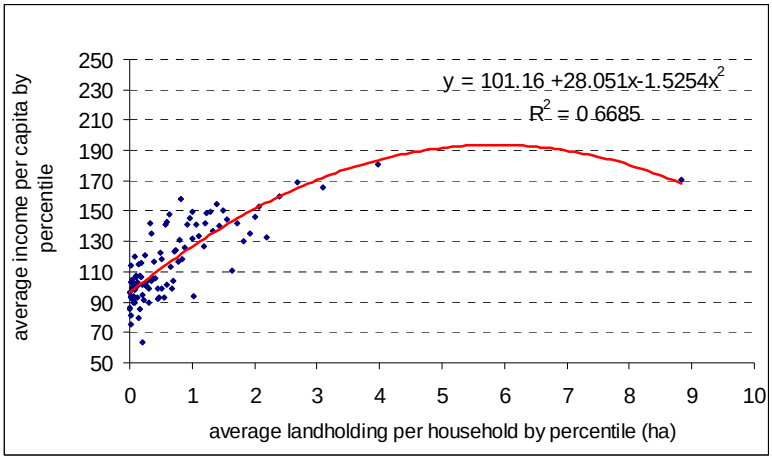
Potential growth within the agriculture sector also depends on available market opportunities. Exploring further export opportunities could increase the size of the market for many agricultural commodities produced in Rwanda, which would in turn increase the farmer incomes. Nevertheless, staple foods and livestock still account for the lion's share of income for most poor smallholders. Potential demand for such commodities is primarily contingent on the size of domestic and regional markets. In order to better understand such market opportunities, it is necessary to understand the dynamics of household demand.

Household income appears to be a primary factor in determining consumption patterns and changes. As shown in the discussion above, limited land is an indicator of

[2]Among these 598 rural households, only two reported producing both tea and coffee.

income inequality across the three rural groups. We run a regression to formalize this relationship by using a quadratic functional form. There is strong correlation between the size of landholdings and household income, but the relationship is not linear (Figure 2). The x axis represents the average size of landholding for each percentile of rural households, ranking from low (including zero) to high, while the y axis represents average annual income per capita for the same percentile of households (in U.S. dollars).[3] The R^2 of the regression is 0.67. Continuing to look at household percentiles with average landholdings of less than 1 hectare (75 percent of all rural households), more than 85 percent have average annual incomes below the national poverty line of US$129. Moreover, 48 percent of households in the national lowest income quintile also fall into Rural Group 1, with landholdings of less than 0.3 hectare (Table 9a).[4] On the other hand, 35 percent of households in the country's highest income quintile also fall into Rural Group 3. The per capita income of households in Rural Group 1 is 30 percent lower than the per capita income of households in Rural Group 3. Even within each income quintile (except for the third), the per capita income of households in Rural Group 1 is always the lowest (Table 9b).

Figure 2. Household Income and Landholding Distribution, by Rural Household Percentile



Source: Calculated by authors from the 1999–2001 EICV.

[3]Constrained by the quality of income data in the survey, total per capita expenditure was used to represent income; this may overestimate the income of poor households and underestimate that of wealthy households.

[4]Household-level consumption expenditure, as opposed to total income, is used to calculate income quintiles given significant underreporting of household-level income in the survey.

Table 9a. Share of Households in each Income Quintile, by Household Group (percent)

Grouping	Quintile					Total
	Lowest	Second	Third	Fourth	Highest	
Rural Group 1	47.9	43.3	36.9	32.4	26.0	36.5
Rural Group 2	25.8	30.0	31.8	31.3	28.6	29.5
Rural Group 3	16.6	16.9	21.4	26.5	35.1	24.1
Urban	9.7	9.7	9.9	9.7	10.3	9.9

Source: Calculated by authors from the 1999–2001 EICV.

Table 9b. Per Capita Annual Income in each Income Quintile by Household Groups (U.S. dollars)

Grouping	Quintile					Total
	Lowest	Second	Third	Fourth	Highest	
Rural Group 1	57.5	112.1	163.7	231.0	413.3	168.6
Rural Group 2	59.9	113.1	163.6	230.9	429.5	198.7
Rural Group 3	61.0	112.6	161.6	235.1	443.3	239.4
Urban	105.7	192.8	286.8	437.9	867.4	378.8
National	63.8	120.9	176.3	254.1	477.3	218.6

Source: Calculated by authors from the 1999–2001EICV.

While there is a significant income gap across rural groups, given that the majority of households in each rural group have low incomes, there is no significant difference in consumption patterns across groups. Instead, consumption patterns vary among income quintiles, especially between the lowest four quintiles, on the one side, and the highest quintile, on the other. For this reason, the following discussion focuses on income quintiles. According to 1999–2001 EICV, agricultural consumption accounts for almost 90 percent of total consumption expenditure by rural households. The share for agricultural consumption does not change significantly among the first four low-income quintiles (at 89–90 percent) and only begin to differ in the highest income quintile, in which the agricultural consumption share falls to 85 percent (Table 10a).

Table 10a. Average Budget Share by Income Quintile

	Quintile	Maize	Rice	Sorghum	Wheat	Cassava	Potatoes	Sweet potatoes	Other roots	Beans	Peas
Rural	Lowest	4.5	0.6	4.2	0.5	8.1	8.1	16.4	2.0	14.8	0.3
	Second	4.9	0.5	3.4	0.3	8.7	7.6	20.9	2.3	13.7	0.3
	Third	4.7	0.7	2.6	0.4	7.6	7.9	19.8	3.7	12.6	0.3
	Fourth	4.3	0.9	2.9	0.4	7.9	6.2	17.7	4.4	13.3	0.2
	Highest	3.5	1.1	2.4	0.4	5.6	4.2	12.6	3.5	9.6	0.2
	Average	4.1	0.9	2.8	0.4	7.0	5.9	16.1	3.5	11.7	0.2
Urban	Lowest	1.4	4.9	1.7	0.9	5.1	8.1	4.9	0.5	8.3	0.1
	Second	1.7	4.9	1.6	1.4	4.2	5.8	2.8	0.5	5.4	0.0
	Third	1.1	4.8	1.1	1.5	3.1	4.8	1.9	0.4	4.0	0.1
	Fourth	0.6	5.1	0.8	2.3	2.0	3.5	1.2	0.3	2.6	0.1
	Highest	0.3	2.8	0.4	1.8	1.2	2.1	0.5	0.1	1.4	0.1
	Average	0.7	4.0	0.8	1.8	2.2	3.5	1.4	0.2	2.9	0.1
National	Lowest	4.4	0.7	4.0	0.5	8.1	8.0	16.3	2.1	14.7	0.3
	Second	4.7	0.8	3.3	0.3	8.2	7.5	19.9	2.3	13.1	0.3
	Third	4.4	1.1	2.5	0.4	7.6	7.6	18.3	3.4	12.3	0.2
	Fourth	4.0	1.3	2.6	0.5	7.2	6.1	15.7	4.0	12.0	0.2
	Highest	2.5	1.9	1.9	0.9	4.3	3.6	8.7	2.4	7.1	0.2
	Average	3.5	1.4	2.4	0.6	6.1	5.4	13.4	2.9	10.1	0.2

Table 10a. Continued.

	Quintile	Bananas	Peanuts	Soybeans	Vegetable oil	Vegetables	Fruits	Sugar	Coffee	Tea	Home-processed food
Rural	Lowest	3.1	0.2	0.4	1.2	14.6	2.4	0.4	0.0	0.0	3.7
	Second	4.8	0.6	0.8	1.1	10.8	2.2	0.5	0.0	0.0	4.1
	Third	5.8	0.6	0.8	1.0	10.1	1.8	0.6	0.0	0.0	4.9
	Fourth	8.7	1.0	0.8	1.1	7.8	1.6	0.7	0.0	0.0	4.9
	Highest	10.5	1.7	0.9	1.1	5.5	1.8	1.1	0.0	0.0	12.4
	Average	8.2	1.1	0.8	1.1	7.9	1.8	0.8	0.0	0.0	8.0
Urban	Lowest	3.0	0.8	0.0	3.5	8.5	1.5	4.5	0.0	0.5	1.6
	Second	3.3	0.9	0.0	3.6	7.4	2.0	4.3	0.0	0.3	1.2
	Third	3.5	0.7	0.1	3.5	6.4	1.5	3.7	0.0	0.3	1.7
	Fourth	2.9	0.7	0.1	3.7	6.0	1.6	3.7	0.0	0.3	1.0
	Highest	2.0	0.4	0.0	2.6	4.9	1.3	2.5	0.1	0.2	0.6
	Average	2.6	0.6	0.0	3.1	5.8	1.5	3.3	0.0	0.3	1.0
National	Lowest	3.4	0.2	0.4	1.3	14.0	2.3	0.6	0.0	0.0	3.6
	Second	4.6	0.7	0.8	1.2	10.8	2.1	0.7	0.0	0.0	3.7
	Third	6.2	0.7	0.8	1.2	9.6	1.7	0.9	0.0	0.0	4.8
	Fourth	8.4	1.0	0.7	1.4	7.4	1.7	1.1	0.0	0.1	4.9
	Highest	8.1	1.4	0.6	1.7	5.3	1.7	1.7	0.0	0.1	9.4
	Average	7.2	1.0	0.7	1.5	7.5	1.8	1.3	0.0	0.1	6.7

Table 10a. Continued.

	Quintile	Beverage	Beef	Goat meat	Poultry	Other meat	Fish	Egg	Milk	Nonfood
Rural	Lowest	1.5	0.1	0.1	0.1	0.2	0.8	0.0	0.4	11.3
	Second	1.0	0.2	0.1	0.1	0.2	0.7	0.0	0.5	9.8
	Third	0.9	0.2	0.1	0.1	0.2	0.5	0.0	0.9	11.1
	Fourth	0.8	0.4	0.3	0.1	0.3	0.4	0.1	1.5	11.5
	Highest	1.1	0.8	0.5	0.6	0.4	0.5	0.2	2.6	15.2
	Average	1.0	0.5	0.3	0.3	0.3	0.5	0.1	1.7	12.8
Urban	Lowest	2.0	2.6	0.0	0.1	0.1	1.3	0.2	1.5	32.5
	Second	2.4	4.1	0.1	0.3	0.1	1.7	0.3	2.3	37.5
	Third	3.0	3.9	0.1	0.4	0.1	1.5	0.3	3.6	42.8
	Fourth	3.7	4.0	0.0	0.4	0.1	1.4	0.5	3.7	47.8
	Highest	4.4	3.2	0.1	0.5	0.0	1.2	0.6	3.3	61.3
	Average	3.7	3.6	0.1	0.4	0.1	1.4	0.5	3.2	51.3
National	Lowest	1.5	0.3	0.1	0.0	0.2	0.8	0.0	0.4	11.8
	Second	1.1	0.3	0.1	0.1	0.2	0.7	0.0	0.6	11.7
	Third	1.1	0.6	0.1	0.1	0.2	0.6	0.1	1.0	12.7
	Fourth	1.0	0.8	0.3	0.2	0.2	0.6	0.1	1.6	14.9
	Highest	2.0	1.6	0.3	0.6	0.3	0.8	0.3	3.0	27.7
	Average	1.5	1.1	0.3	0.3	0.3	0.7	0.2	2.0	19.8

Source: Calculated by authors from the 1999–2001EICV.

Root crops account for one-third of total consumption expenditure for rural households as a whole, and the shares are much higher among the low-income quintiles than that for the highest (Table 10a). Grain consumption is about 8.3–9.8 percent of total consumption expenditure for rural households (except for households in the highest income quintile). However, the low-income households consume more coarse grains, such as sorghum, while the high-income households consume more rice and wheat. Among other food crops, bananas seem to be more consumed by the high-income quintiles. With increasing incomes, households also spend more on livestock products and beverages, while for the low-income quintiles livestock constitutes a very small share of the household budget.

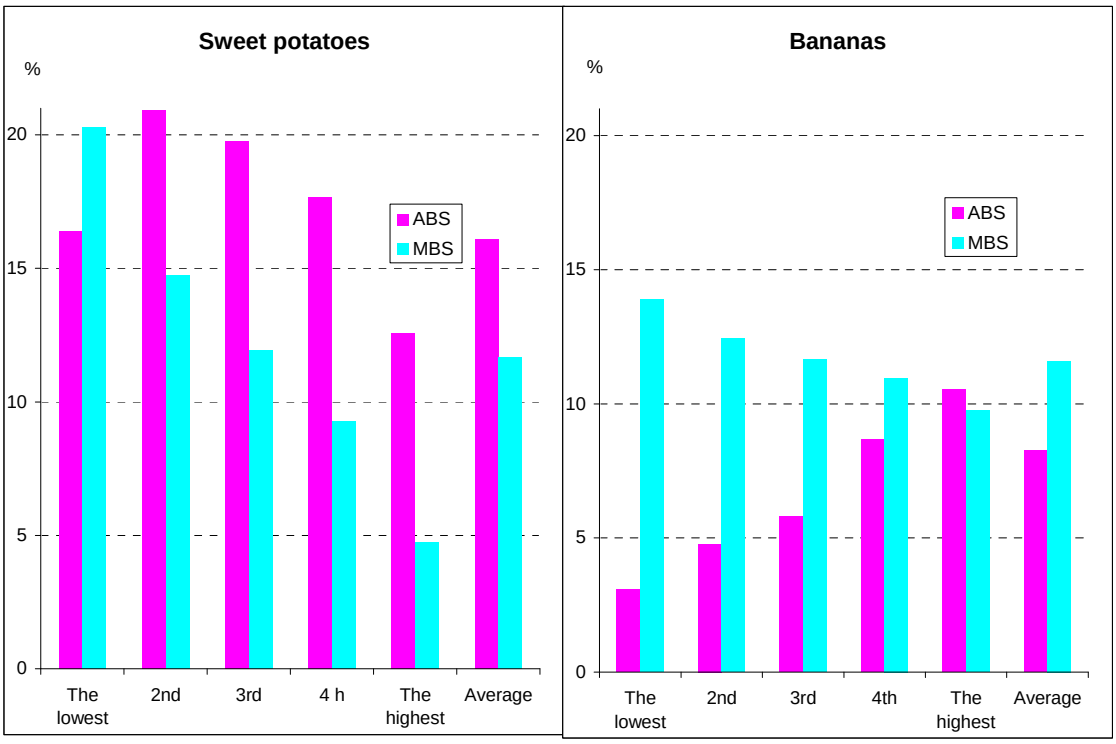
Urban households have quite different spending patterns from rural households. Total agricultural consumption is less than 50 percent of total consumption expenditure for the urban households as a whole, but the share is still quite high (68 percent) for the lowest income quintile. While the share of total grain consumption is comparable with the share for rural households, urban households spend much more on rice, and then on wheat, compared with rural households. Moreover, urban households spend quite a small share of their budgets on root crops. Bananas become less important for urban households, especially those in the high-income quintiles, while livestock consumption significantly increases among urban households.

The above discussions are based on calculated average budget shares (ABS) for different household groups. The ABS is the share of total current income actually spent on each commodity. To capture the dynamics of consumption patterns, it is important to look at the marginal budget share (MBS), which is the share of each additional unit of income likely to be spent on each commodity. Comparing MBS with ABS can increase our understanding of which commodities households would likely prefer to consume as their income increases.

The MBS needs to be econometrically estimated using complete household survey data. In this study, a semi-log inverse function (RSLI), suggested by King and Byerlee (1978), was used to estimate the marginal propensity to consume. Not

surprisingly, there is no significant difference between the marginal and average budget shares of agricultural consumption for the rural households, except for those in the highest income quintile (Table 10b), a typical phenomenon observed among very low-income rural households with in developing countries. For each increase of Rwandan Franc (RWF) in income, an average rural household will spend 0.84 RWF on agricultural consumption. The marginal share of agricultural consumption only falls for households in the highest income quintile—from 85 percent in ABS to 74 percent of MBS. While agricultural consumption is still the dominant expenditure when income increases in rural households, marginal spending indicates different patterns from the commodity-level's ABS. For example, the MBS for root crops and bananas combined is 37 percent for rural households compared with an ABS of 40 percent. For sweet potatoes, the MBS is lower than the ABS in all income quintiles except the lowest, while MBS is larger than the ABS for bananas in all income quintiles but the highest. This indicates substitution occurring between these two commodities as farm income increases (Figure 3).

Figure 3. Average and Marginal Budget Share for Rural Household by Income Quintile



Source: Calculated by authors from the 1999–2001EICV.

Table 10b. Marginal Budget Share by Income Quintile

	Quintile	Maize	Rice	Sorghum	Wheat	Cassava	Potatoes	Sweet potatoes	Other roots	Beans	Peas
Rural	Lowest	7.8	1.0	2.3	0.0	9.7	8.2	20.3	5.8	16.8	0.2
	Second	5.8	1.2	2.3	0.2	7.2	5.7	14.8	4.5	12.4	0.2
	Third	4.7	1.2	2.3	0.3	5.9	4.5	11.9	3.9	10.2	0.2
	Fourth	3.8	1.3	2.3	0.4	4.7	3.3	9.3	3.3	8.1	0.2
	Highest	2.1	1.4	2.4	0.6	2.6	1.3	4.7	2.3	4.6	0.1
	Average	4.6	1.2	2.3	0.3	5.8	4.4	11.7	3.8	10.0	0.2
Urban	Lowest	0.5	7.8	0.6	4.1	1.5	3.1	0.0	0.4	1.0	0.1
	Second	0.3	5.6	0.4	3.2	1.0	2.3	0.0	0.3	0.7	0.1
	Third	0.2	4.3	0.3	2.7	0.8	1.7	0.0	0.2	0.5	0.1
	Fourth	0.1	2.9	0.2	2.1	0.5	1.2	–0.1	0.1	0.3	0.1
	Highest	–0.1	0.6	0.0	1.2	0.1	0.2	–0.1	-0.1	0.0	0.1
	Average	0.2	3.9	0.3	2.5	0.7	1.6	–0.1	0.1	0.4	0.1
National	Lowest	5.4	4.2	2.7	1.2	7.1	6.5	12.6	4.5	11.9	0.2
	Second	3.7	3.6	2.1	1.3	5.0	4.6	8.5	3.2	8.3	0.2
	Third	2.8	3.2	1.7	1.3	3.9	3.7	6.3	2.5	6.4	0.1
	Fourth	2.0	2.9	1.4	1.4	2.8	2.8	4.2	1.8	4.5	0.1
	Highest	0.4	2.3	0.7	1.5	0.9	1.1	0.4	0.5	1.2	0.1
	Average	2.7	3.2	1.7	1.3	3.7	3.6	6.0	2.4	6.1	0.1

Table 10b. Continued.

	Quintile	Bananas	Peanuts	Soybeans	Vegetable oil	Vegetables	Fruits	Sugar	Coffee	Tea	Home process food
Rural	Lowest	13.9	–4.8	1.0	1.2	5.2	1.2	0.9	0.0	0.1	–9.0
	Second	12.4	–1.2	0.9	1.2	4.3	1.4	1.1	0.0	0.1	2.3
	Third	11.7	0.6	0.8	1.2	3.9	1.5	1.2	0.0	0.1	8.0
	Fourth	11.0	2.4	0.7	1.2	3.4	1.6	1.3	0.0	0.1	13.4
	Highest	9.7	5.3	0.6	1.2	2.6	1.8	1.5	0.0	0.1	22.7
	Average	11.6	0.8	0.8	1.2	3.8	1.5	1.3	0.0	0.1	8.6
Urban	Lowest	3.4	0.9	0.1	5.4	7.2	2.6	4.7	–0.1	0.3	1.3
	Second	2.8	0.7	0.1	4.2	5.7	2.1	3.6	0.0	0.2	0.9
	Third	2.3	0.5	0.1	3.4	4.8	1.8	2.9	0.0	0.2	0.6
	Fourth	1.9	0.4	0.0	2.5	3.8	1.4	2.2	0.1	0.2	0.4
	Highest	1.2	0.1	0.0	1.2	2.3	0.9	1.0	0.1	0.1	0.0
	Average	2.2	0.5	0.1	3.1	4.6	1.7	2.7	0.0	0.2	0.6
National	Lowest	14.0	0.6	0.9	2.9	5.5	2.1	3.0	–0.1	0.2	8.4
	Second	10.6	1.0	0.7	2.6	4.6	1.9	2.7	0.0	0.2	7.9
	Third	8.8	1.2	0.5	2.5	4.2	1.7	2.5	0.0	0.2	7.6
	Fourth	7.1	1.4	0.4	2.3	3.8	1.6	2.3	0.0	0.2	7.3
	Highest	4.1	1.8	0.2	2.0	3.0	1.4	2.0	0.1	0.2	6.8
	Average	8.6	1.3	0.5	2.4	4.1	1.7	2.5	0.0	0.2	7.6

Table 10b. Continued.

	Quintile	Beverage	Beef	Goat meat	Poultry	Other meat	Fish	Egg	Milk	Nonfood
Rural	Lowest	0.3	–0.2	0.1	0.3	0.6	0.5	0.2	7.4	9.0
	Second	0.7	0.4	0.4	0.5	0.5	0.5	0.2	6.7	13.2
	Third	0.9	0.7	0.5	0.6	0.5	0.5	0.2	6.4	15.3
	Fourth	1.1	1.0	0.7	0.7	0.4	0.5	0.3	6.1	17.4
	Highest	1.5	1.5	0.9	0.9	0.4	0.5	0.3	5.6	20.8
	Average	0.9	0.7	0.5	0.6	0.5	0.5	0.2	6.4	15.6
Urban	Lowest	5.5	6.5	–0.1	0.5	0.0	2.0	0.7	6.0	33.9
	Second	5.1	5.1	0.0	0.6	0.0	1.6	0.7	5.2	47.8
	Third	4.8	4.2	0.1	0.6	0.0	1.3	0.7	4.6	56.5
	Fourth	4.5	3.3	0.1	0.6	0.1	1.0	0.7	4.1	65.4
	Highest	4.1	1.8	0.2	0.7	0.1	0.5	0.7	3.2	79.9
	Average	4.7	4.0	0.1	0.6	0.1	1.2	0.7	4.5	58.7
National	Lowest	0.7	2.4	0.5	0.6	0.5	1.1	0.2	8.0	–7.9
	Second	1.7	2.5	0.4	0.6	0.4	1.0	0.3	6.8	13.9
	Third	2.2	2.5	0.4	0.6	0.3	1.0	0.4	6.1	25.3
	Fourth	2.6	2.6	0.4	0.7	0.3	0.9	0.5	5.5	36.3
	Highest	3.5	2.7	0.4	0.7	0.2	0.8	0.6	4.4	56.0
	Average	2.2	2.5	0.4	0.7	0.3	1.0	0.4	6.1	26.8

Source: Calculated by authors from the 1999–2001 EICV.

Rural households in the highest income quintile display quite different marginal propensity to consume compared with their low-income neighbors. For example, the MBS for root crops for this group falls to 10.9 percent, compared with an ABS of 25.8 percent. Therefore, while these households reduce their overall grain consumption only slightly, their demand for rice actually increases with higher income. In contrast, wealthy rural households almost double their livestock consumption when they have more income, as indicated by a MBS of 12.3 percent and an ABS of 6.8 percent.

In urban areas, poor households (those in the lowest two income quintiles) have a similar MBS and ABS for total agricultural consumption, but they spend less on root crops and more on grains with increased income. Of the grain products, the urban poor consume more rice and wheat, and less sorghum with additional income. Only the poorest households (those in the lowest income quintile), consume more maize as their income increases, as indicated by a higher MBS than ABS for maize (Table 10b).

Declines in the marginal propensity to consume of some staple crops (such as root crops) may generate a misunderstanding of market opportunities. For example, at the national level, the MBS for sorghum is 30 percent below the ABS (1.7 percent compared with 2.4 percent). One could assume that this implies an absolute decline in national sorghum consumption when per capita income rises. But determining this correctly depends on an analysis of the absolute consumption patterns by income groups, in addition to spending shares across commodities. According to the 1999–2001 EICV, Rwanda spent US$42 million on sorghum consumption, including home consumption by farmers. Processed sorghum products, excluding beer made from sorghum, are also included. Surprisingly, households in the highest income quintile consumed more sorghum in terms of value than those in the four lower income quintiles (Table 11). The national average value of sorghum consumption is US$26 per household per year, while for the rural households in the highest income quintile it is US$42. In comparison, the average value in the lowest income quintile is only US$14 (Table 12). A similar situation exists for other staple and root crops, such as maize and cassava, for which the marginal propensity to consume falls with income growth. On average, a rural household in the

highest income quintile spends US$61 on maize and US$99 on cassava each year, while those in the lowest income quintile spend only US$14 on maize and US$26 on cassava.

The significant income, and hence expenditure, gap is the key reason for the difference in the absolute value of staple crop consumption between poor and nonpoor households. The total consumption expenditure of an average poor rural household in the lowest income quintile is only one-sixth the level for an average rural household in the highest income quintile, despite the often smaller ABS and MBS reported for wealthy households, especially for certain staple foods. All these mean that, in absolute terms, wealthy households spend four times as much as poor households on agricultural consumption.

Both budget share and absolute spending analyses indicate that domestic demand for staples in Rwanda will need to increase rapidly to achieve pro-poor growth and redress the huge gap in the consumption of staple foods. If growth favors wealthy households, market opportunities for many staple foods will be limited. Wealthier consumers generally spend more on high-value and processed agricultural commodities and even more on nonagricultural commodities like industrial goods and services. This analysis helps to illustrate that market opportunities for agriculture, especially for staple foods and livestock sectors, critically depend on broad-based agricultural growth. This can directly increase the incomes of the majority of farmers and thus increase their consumption levels. When broad-based agricultural growth is rooted in increased agriculture productivity, food prices can decrease without lowering farmers' incomes. Poor urban consumers also benefit from cheaper prices through increased consumption levels. In the next section, linkages between broad-based agricultural growth and poverty reduction are analyzed using the EMM model developed for the study.

Table 11. Total Commodity Expenditure by Income Quintile (thousand U.S. dollars)

	Quintile	Maize	Rice	Sorghum	Wheat	Cassava	Potatoes	Other roots
Rural	Lowest	3,738	500	3,519	414	6,756	6,804	15,341
	Second	7,744	873	5,481	494	13,829	12,059	37,139
	Third	10,874	1,567	5,923	828	17,622	18,318	54,149
	Fourth	14,152	2,843	9,487	1,215	26,034	20,332	72,489
	Highest	21,281	6,605	14,733	2,419	34,276	25,461	98,424
	Total	57,790	12,388	39,142	5,369	98,518	82,975	277,541
Urban	Lowest	238	865	301	156	889	1,410	955
	Second	551	1,547	509	442	1,314	1,820	1,027
	Third	526	2,328	549	729	1,513	2,314	1,108
	Fourth	423	3,760	618	1,703	1,433	2,565	1,067
	Highest	488	4,064	645	2,669	1,762	2,978	837
	Total	2,227	12,564	2,621	5,700	6,911	11,087	4,994
National	Lowest	3,977	1,365	3,820	570	7,646	8,215	16,296
	Second	8,295	2,421	5,990	936	15,143	13,879	38,166
	Third	11,401	3,895	6,471	1,557	19,135	20,632	55,257
	Fourth	14,575	6,603	10,104	2,918	27,467	22,897	73,556
	Highest	21,769	10,669	15,379	5,088	36,038	28,440	99,261
	Total	60,017	24,952	41,764	11,069	105,429	94,062	282,535

Table 11. Continued.

	Quintile	Bananas	Pulse/oilseed	Other crops	Beverage	Livestock	Total agriculture	Total non-agriculture	Total expenditure
Rural	Lowest	2,571	13,197	14,532	5,309	1,395	74,078	9,426	83,504
	Second	7,629	24,549	21,559	9,920	2,797	144,074	15,592	159,666
	Third	13,427	33,060	28,994	15,912	4,861	205,534	25,577	231,110
	Fourth	28,579	50,374	33,486	22,589	9,877	291,458	37,730	329,188
	Highest	64,498	75,346	51,772	89,570	34,655	519,042	93,215	612,256
	Total	116,705	196,527	150,345	143,299	53,586	1,234,186	181,539	1,415,725
Urban	Lowest	519	1,616	2,631	1,246	988	11,815	5,689	17,504
	Second	1,031	2,020	4,416	2,268	2,802	19,748	11,845	31,592
	Third	1,687	2,351	5,801	4,028	4,816	27,749	20,768	48,517
	Fourth	2,115	2,517	8,469	6,062	7,447	38,179	34,931	73,110
	Highest	2,895	2,879	12,908	10,900	12,928	55,954	88,633	144,587
	Total	8,247	11,383	34,226	24,504	28,981	153,445	161,866	315,311
National	Lowest	3,090	14,813	17,163	6,555	2,383	85,893	15,115	101,008
	Second	8,660	26,569	25,976	12,188	5,599	163,822	27,436	191,258
	Third	15,114	35,411	34,796	19,939	9,677	233,283	46,344	279,627
	Fourth	30,695	52,891	41,955	28,651	17,325	329,637	72,661	402,298
	Highest	67,393	78,225	64,681	100,470	47,584	574,996	181,848	756,844
	Total	124,952	207,909	184,570	167,803	82,567	1,387,630	343,405	1,731,036

Source: Calculated by authors from the 1999–2001 EICV.

Table 12. Per Household Annual Commodity Expenditure by Income Quintile (U.S. dollars)

	Quintile	Maize	Rice	Sorghum	Wheat	Cassava	Potatoes	Other roots
Rural	Lowest	14.5	1.9	13.6	1.6	26.2	26.4	59.4
	Second	29.8	3.4	21.1	1.9	53.1	46.3	142.7
	Third	40.0	5.8	21.8	3.0	64.8	67.4	199.2
	Fourth	47.8	9.6	32.0	4.1	87.9	68.7	244.8
	Highest	61.2	19.0	42.4	7.0	98.6	73.2	283.1
	Total	40.3	8.6	27.3	3.7	68.7	57.9	193.5
Urban	Lowest	8.6	31.3	10.9	5.7	32.2	51.0	34.6
	Second	19.6	55.1	18.1	15.7	46.8	64.8	36.6
	Third	17.6	77.7	18.3	24.3	50.5	77.2	37.0
	Fourth	13.2	117.5	19.3	53.2	44.8	80.2	33.4
	Highest	12.2	101.8	16.2	66.9	44.1	74.6	21.0
	Total	14.1	79.7	16.6	36.2	43.9	70.3	31.7
National	Lowest	13.9	4.8	13.4	2.0	26.8	28.7	57.0
	Second	28.8	8.4	20.8	3.2	52.5	48.1	132.4
	Third	37.8	12.9	21.4	5.2	63.4	68.4	183.1
	Fourth	44.4	20.1	30.8	8.9	83.7	69.8	224.1
	Highest	56.2	27.5	39.7	13.1	93.0	73.4	256.1
	Total	37.7	15.7	26.2	7.0	66.2	59.1	177.5

Table 12. Continued.

	Quintile	Bananas	Pulse/oilseed	Other crops	Beverage	Livestock	Total agriculture	Non-agriculture	Total expenditure
Rural	Lowest	10.0	51.1	56.3	20.6	5.4	287	37	323
	Second	29.3	94.3	82.9	38.1	10.7	554	60	614
	Third	49.4	121.6	106.7	58.5	17.9	756	94	850
	Fourth	96.5	170.1	113.1	76.3	33.4	984	127	1,112
	Highest	185.5	216.7	148.9	257.6	99.7	1,493	268	1,761
	Total	81.4	137.0	104.8	99.9	37.4	861	127	987
Urban	Lowest	18.8	58.5	95.2	45.1	35.7	428	206	633
	Second	36.7	71.9	157.2	80.7	99.7	703	422	1,125
	Third	56.3	78.4	193.6	134.4	160.7	926	693	1,619
	Fourth	66.1	78.7	264.7	189.5	232.8	1,193	1,092	2,285
	Highest	72.5	72.1	323.4	273.1	323.9	1,402	2,221	3,623
	Total	52.3	72.2	217.2	155.5	183.9	974	1,027	2,001
National	Lowest	10.8	51.8	60.0	22.9	8.3	301	53	353
	Second	30.0	92.2	90.1	42.3	19.4	568	95	663
	Third	50.1	117.3	115.3	66.1	32.1	773	154	926
	Fourth	93.5	161.2	127.8	87.3	52.8	1,005	221	1,226
	Highest	173.9	201.8	166.9	259.2	122.8	1,484	469	1,953
	Total	78.5	130.6	116.0	105.4	51.9	872	216	1,088

Source: Calculated by authors from the 1999–2001 EICV.

III. MODEST POVERTY REDUCTION FROM BUSINESS AS USUAL SCENARIO

In this section, the EMM and micro-simulation models are used to simulate a scenario of modest growth in both agricultural and nonagricultural sectors over next decade to 2015, based on historical data. Due to the huge 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. Even based on data for 2000–03, growth rates for GDP and agricultural GDP are still as high as 6.4 and 7.9 percent per year, respectively (World Bank 2006). The data from MINAGRI (2006) show that total crop production grew at 6 percent annually between 2000 and 2003, even though 2003 was a drought year. During this period, 40 percent of crop production growth resulted from area expansion, while the remaining 60 percent was due to yield increases (and the majority of the increases represented recovery from the declines of 1994). Obviously, such rapid growth is unsustainable given the land constraint. Consequently, much more modest land-based expansion is assumed in the model, including the promotion of potential double- and intercropping farming practices. Total crop area is assumed to increase by 0.5 percent per year, implying a cumulative increase of about 100,000 hectares of cultivated area from 1.7 million hectares in 2003 to 1.8 million hectares by 2015. The growth rate for individual crop yield is chosen to approximate their national average growth rate from 2000 to 2005, with certain adjustments for some crops with particularly high yields in this period (for example, rice grew at 10 percent and vegetables and fruits grew at more than 20 percent annually over this period). The variation in growth across provinces is also taken into account.

2003 was chosen as the base-year for the model, which means that the initial yield and area levels by crop used in the model are those reported by MINAGRI for 2003. To make sure that the base year does not significantly affect the model results, the 2003 data were also compared with average national levels for each crop for 2000–03. The comparison is reported in Table 13, which shows that deviations from 2003 data are modest. Table 14 reports national level yield and cultivated area for the base year by crop

and livestock production, and annual growth rates for yield, area, and crop or livestock output.

Table 13. Comparison of the Model's Base Year, 2003, and the 2000–03 Actual Average (2000-03 actual average is 1.00)

Commodity	Area	Production
Cereals	1.06	1.04
Sorghum	1.04	0.99
Maize	1.01	0.99
Wheat	1.55	1.63
Rice	1.29	1.44
Pulses	1.02	0.99
Beans	1.00	0.97
Groundnuts	1.09	1.09
Soybeans	1.17	1.20
Peas	1.12	1.17
Bananas	1.00	1.08
Roots and tubers	0.98	1.00
Potatoes	1.10	1.08
Sweet potatoes	0.83	0.80
Cassava	1.05	1.14
Other roots	1.13	1.23
Vegetables and fruits	1.25	2.13
Total crops	1.02	1.09

Source: Calculated by the authors from MINAGRI (2006).

Table 14a. Baseline Yield and Area, and Annual Growth Rates Used in the Model (National Level)

	Baseline				Growth simulations (scenarios 1 through 19)							
	Yield		Area		Targeted level by 2015		Required annual growth rate in 2005–10 (%)			Assumed growth rate in 2010–15 (%)		
Commodity	2003 level (mt/ha)	Assumed baseline growth rate (%)	2003 level (000 ha)	Assumed baseline growth rate (%)	Yield (mt/ha)	Area (000 ha)	Yield	Area	Production	Yield	Area	Production
Maize	0.8	2.3	104	1.4	1.3	160	4.6	3.3	8.1	3.7	5.4	9.3
Rice	3.7	2.9	8	1.8	6.3	19	3.7	9.2	13.2	3.5	9.7	13.5
Sorghum	0.9	2.0	184	0.5	1.0	193	2.0	0.5	2.5	2.0	0.5	2.5
Wheat	0.7	3.2	21	0.8	1.6	23	7.1	0.8	7.9	7.0	0.9	8.0
Cassava	7.5	1.9	137	0.0	9.5	153	2.0	0.9	2.9	2.0	1.2	3.3
Potatoes	8.2	2.3	134	1.2	12.1	170	3.4	2.0	5.4	4.0	2.8	6.9
Sweet potatoes	5.9	1.1	149	0.0	7.5	150	2.2	0.1	2.3	3.0	0.1	3.1
Other roots	5.1	1.8	28	0.0	6.8	28	2.5	0.1	2.5	3.0	0.1	3.1
Beans	0.7	1.1	363	0.0	1.0	361	3.4	–0.1	3.3	5.2	0.0	5.2
Peas	0.5	1.5	35	0.2	0.8	36	3.5	0.2	3.7	5.2	0.2	5.4
Bananas	6.7	3.0	363	1.0	10.0	402	3.4	1.0	4.5	3.8	1.0	4.9
Peanuts	0.6	1.6	17	0.7	0.8	18	2.9	0.7	3.6	3.9	0.7	4.7
Soybeans	0.6	1.3	37	0.7	0.9	52	4.2	2.6	7.0	6.2	4.5	11.0
Vegetables	12.3	6.0	45	0.7	27.0	47	7.0	0.4	7.4	7.9	0.4	8.3
Fruits	12.3	6.0	13	0.7	24.8	14	6.1	0.6	6.7	6.1	0.6	6.7
Sugar	3.0	6.0	2	0.5	6.2	2	6.1	0.6	6.7	6.2	0.1	6.3
Coffee	0.7	1.0	31	0.1	1.2	46	5.2	3.5	8.8	5.2	4.7	10.1
Tea	1.2	1.0	12	0.1	2.8	25	3.0	6.7	9.9	2.9	8.9	12.0
Pyrethrum	0.2	6.7	3	0.5	0.4	15	6.7	14.7	22.4	6.7	18.5	26.5
Total			1,686	0.5		1,914		1.0			1.5	

Source: Calculated by the authors from MINAGRI (2006).

Table 14b. Initial Production and Annual Growth Rates Used in the Model (National Level)

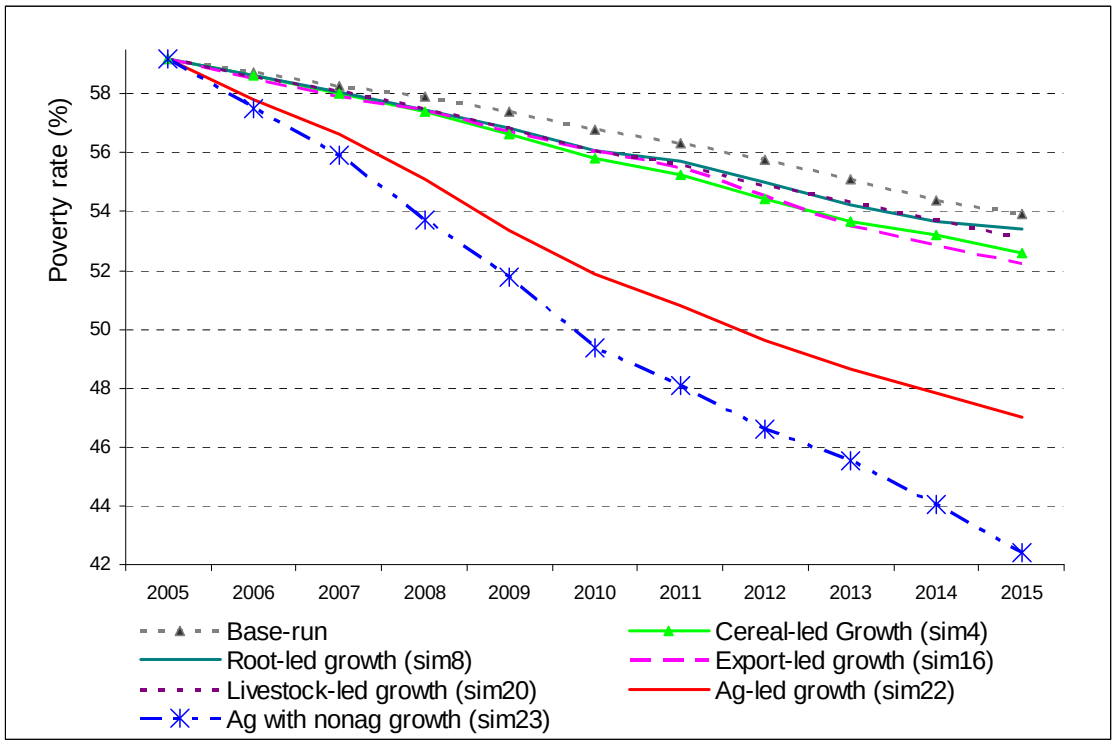
Commodity	Base year 2003		Growth simulations (Scenarios 13 through19)	
	Production (000 metric tons) 2003 level	Growth rate	Production (000 metric tons) Targeted 2015 level	Growth rate
Vegetable oil	0.9	1.0	2.0	5.5
Beverage	457.1	3.5	746.0	4.3
Beef	12.7	4.3	22.4	4.9
Mutton	8.6	4.3	15.2	5.0
Poultry	3.4	4.3	9.6	10.5
Other meat	16.5	4.0	28.8	4.9
Fish	7.3	3.0	14.0	6.2
Egg	1.8	4.0	6.8	13.9
Milk	129.4	4.5	323.0	8.6
Hides/skins	1.9	4.3	3.3	4.9
Industry (million $US)	286.4	3.8	552.0	6.0
Services (million $US)	478.4	4.3	1036.0	6.5

Source: Calculated by the authors from MINAGRI (2006).

The EMM model simulation results indicate that, with modest growth in agricultural production, together with 4 percent annual growth in the nonagricultural sector, national GDP grows at 3.88 percent annually and per capita GDP grows at about 1.15 percent. The EMM model simulation results also show a modest reduction in national poverty and greater food insecurity with such growth. The poverty rate falls only modestly to 54 percent by 2015 (Figure 4), compared with 60 percent in 2001, based on the 1999–2001 EICV,[5] although the rate was higher in rural areas (66 percent) than in urban areas (14 percent). With such a modest reduction, the poverty population would increase as a result of population growth from the current level of 4.8 million, to 5.9 million by 2015. Moreover, the apparent gap between supply and demand would continue to increase, making Rwanda more dependent on imports or food aid to meet basic needs for many staple crops and livestock products.

[5] The model simulated the national poverty rate at 59.2 percent in 2005 (Table 16, part 4).

Figure 4. National Poverty Rate in Model Simulations



Source: Model simulation results.
Notes: The GDP growth rate under each scenario is as follows: base-run: 3.88 percent, cereal-led growth: 4.23 percent (Simulation 4), root-led growth: 3.97 percent (Simulation 8), three export-crop-led growth: 4.18 percent (Simulation 16), livestock-led growth: 4.22 percent (Simulation 20), agriculture-led: 5.04 percent (Simulation 22), and agricultural growth with nonagriculture: 6.24 percent (Simulation 23).

IV. WHICH SECTORS CONTRIBUTE THE MOST TO GROWTH AND POVERTY REDUCTION?

The main purpose for developing the EMM model was to simulate targeted agricultural subsector growth and to assess the impacts of such growth on overall economic growth and poverty reduction. National growth projections are available for 17 agricultural subsectors (see Table 1, column 3). While growth targets are not available for sweet potatoes, bananas, and beans, given their importance to both food security and poverty reduction, 2.3–3.7 percent annual yield growth is assumed for these commodities in the simulations. Thus, based on actual growth targets and these additional estimates, 23 scenarios were designed for analysis (Table 15). Under each scenario, additional growth is assumed for a specific agricultural subsector between 2006 and 2015, while productivity growth in the other subsectors is maintained at baseline levels. Scenarios 1–4 focus on grain sector growth and national targets for maize, rice, and wheat (Scenarios 1–3, respectively). Scenario 4 combines these three scenarios, together with modest growth in sorghum, to simulate joint growth in grain production. Similarly, Scenarios 5–8 focus on growth in root crops, Scenario 9 focuses on bananas, and Scenarios 10–12 focus on pulses and oilseed crops. Scenarios 13–15 target the three main export crops—coffee, tea, and pyrethrum—and Scenario 16 combines the three traditional export crops with the horticulture (vegetables) to capture potential growth in both traditional and nontraditional export commodities. Scenarios 17–20 focus on livestock growth, and given that hides/skins are a byproduct of large animal production, growth in these products is included under Scenario 18. Scenario 21 simulates joint growth of all agricultural staples simulated under Scenarios 1–3, 5–7, 9–11, and 17–19, and Scenario 22 combines growth in all agricultural subsectors, including both the staple crops and livestock modeled under Scenario 21 and the export crops modeled under Scenario 16. Finally, Scenario 23 considers comparable growth in the nonagricultural sectors, in addition to growth in the agricultural sector.

Table 15. Model Scenarios

	Grains				Root crops			
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7	Scenario 8
Maize	✓			✓				
Rice		✓		✓				
Wheat			✓	✓				
Sorghum				✓				
Cassava					✓			✓
Potatoes						✓		✓
Sweet potatoes							✓	✓

	Bananas	Pulses/oilseed		
	Scenario 9	Scenario 10	Scenario 11	Scenario 12
Bananas	✓			
Beans		✓		✓
Soybeans			✓	✓

	Export crops				Livestock			
	Scenario 13	Scenario 14	Scenario 15	Scenario 16	Scenario 17	Scenario 18	Scenario 19	Scenario 20
Coffee	✓			✓				
Tea		✓		✓				
Pyrethrum			✓	✓				
Vegetables and fruits				✓				
Poultry					✓			✓
Egg					✓	✓		✓
Beef						✓		✓
Mutton						✓		✓
Other meat						✓		✓
Milk								✓
fish						✓	✓	✓
Hides						✓		✓
Industry	✓	✓	✓	✓				✓

Table 15. Continued.

	Staples Scenario 21		All agriculture Scenario 22		With nonagriculture Scenario 23
Maize	✓		✓		✓
Rice	✓		✓		✓
Wheat	✓		✓		✓
Cassava	✓		✓		✓
Potatoes	✓		✓		✓
Sweet potatoes	✓		✓		✓
Bananas	✓		✓		✓
Beans	✓		✓		✓
Soybeans	✓		✓		✓
Coffee			✓		✓
Tea			✓		✓
Pyrethrum			✓		✓
Poultry	✓		✓		✓
Egg	✓		✓		✓
Beef	✓		✓		✓
Mutton	✓		✓		✓
Other meat	✓		✓		✓
Milk	✓		✓		✓
Fish	✓		✓		✓
Hides			✓		✓
Industry			✓		✓
Services					✓

National growth projections often take the form of production and area expansion. For the purpose of the model, all the production and area targets were converted into average annual growth rates for 2006–15, based on the projected level for 2005. The growth rates used in the simulations are reported in the second part of Table 14.

The Six Percent CAADP Growth Target is Reachable

Scenario 22 models the joint effects growth across agricultural subsectors. To reach the desired targets at the agricultural subsectoral level by 2015, agricultural GDP would need increase at 6.09 percent from 2006 to 2015—almost doubling baseline growth. This represents total GDP growth of 5.04 percent, compared with the 3.88

percent baseline level. If additional yearly growth of more than 6 percent is assumed to occur in the nonagricultural sector, which is comparable with targets set by the government (Scenario 23), interlinkages between nonagriculture and agriculture fuel agricultural growth to 6.17 percent per year, while total GDP growth rises to 6.24 percent per year (Table 16 part 1). At this rate, per capita GDP grows at 3.44 percent annually, almost tripling the baseline level. With such high growth rates, national poverty falls to 42.4 percent—17 percentage points lower than the rate in 2005.

Differential Income and Poverty Reduction 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; Zhang and Kanbur 2004). Differences in poverty reduction and income growth across regions have also been observed in China (Chen and Ravallion 2000). Thus, it is essential to further assess income and poverty effects across household groups.

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 smallest landholding (Rural Group 1) appears to benefit less than the other groups under Scenario 23, annual income growth is 6.21 percent per year for this group, compared with 6.33–6.34 percent for the other two groups with greater landholdings (Table 16, part 2). The rural poverty rate falls in all three rural groups, but because the initial poverty rate is much higher in Rural Group 1 (and with relatively slower poverty reduction), the poverty rate for this group remains as high as 56.9 percent by 2015, whereas it falls as low as 34.4 percent for Rural Group 3.

Differences in income growth also seem to relate to whether households are involved in cash crop production. Under Scenario 23, for the rural households that produce cash crops, total income grows at 6.33 percent annually, while for those households without cash crops, income grows at only 6.01 percent per year. As a result,

Table 16. Income Growth and Poverty Reduction in the Model

	Annual growth rate (%) 2005–15	Growth rate under baseline	Growth rate under Scenario 23	Additional growth from baseline
Part 1	GDP	3.88	6.24	2.36
	AgGDP	3.60	6.17	2.57
	Non-AgGDP	4.08	6.28	2.21
	GDP per capita	1.15	3.44	2.29
	AgGDP per capita	0.87	3.37	2.50
	Non-AgGDP per capita	1.34	3.49	2.15
Part 2	Income for rural households with cash crop	3.89	6.33	2.44
	Income for rural households without cash crop (10 percent of total rural households)	3.73	6.01	2.28
	Income for rural male-headed households	3.87	6.37	2.50
	Income for rural female-headed households	3.90	6.18	2.28
	Income for Rural Group 1	3.70	6.21	2.51
	Income for Rural Group 2	3.89	6.33	2.45
	Income for Rural Group 3	3.91	6.34	2.43
Part 3	Staple production	3.76	6.21	2.45
	Grain production	4.12	9.62	5.50
	Root production	2.21	3.27	1.06
	Pulse and oilseed production	1.44	3.69	2.25
	Livestock production	4.28	7.82	3.54
	Export crop production	1.21	9.93	8.72
Part 4	**Poverty by 2015 from targeted growth rate**	**Poverty rate in 2005**	**Poverty rate in 2015**	**Poverty reduction**
	National	59.2	42.4	–16.8
	Rural	64.5	46.6	–17.9
	Rural households with cash crops	62.2	43.6	–18.7
	Rural households without cash crops	88.5	78.3	–10.2
	Rural male-headed	61.9	43.6	–18.4
	Rural female-headed	71.4	54.7	–16.7
	Rural Group 1	73.1	56.9	–16.2
	Rural Group 2	66.0	46.2	–19.8
	Rural Group 3	52.5	34.4	–18.0

Source: Model simulation results.

Note: Table presents results from baseline and growth Scenario 23.The distribution of growth benefit also seems to have certain gender bias. The income growth rate is 6.37 percent per year for rural, male-headed households under Scenario 23, but it is only 6.18 percent for the rural households headed by women. Considering that poverty rate is higher for female-headed households, this additional difference in income growth translates to an even larger gender gap. The poverty rate for rural households headed by men falls from 62.1 percent in 2005 to 43.6 percent by 2015, while the poverty rate for the rural households headed by women falls from 71.4 percent in 2005 to 54.7 percent by 2015 (Table 16, part 4).

the poverty rate for these rural households falls only modestly, from 88.5 percent in 2005 to 78.3 percent by 2015, whereas for rural households with cash crops, it falls from 62.2

percent in 2005 to 43.6 percent by 2015 (Table 16, part 4). More than 10 percent of rural households do not produce cash crops, whether for export or the domestic market. Of these households, 43 percent are headed by women and 60 percent have less than 0.3 hectare of land (that is, they belong to Rural Group 1). Lack of opportunities to produce cash crops contributes not only to the low income levels and high poverty rates among these households, but also to their inability to fully benefit from rapid agricultural growth.

Staple Crop Growth is More Pro-Poor

The above analysis indicates differing growth–poverty linkages at the agricultural subsector and household levels. Understanding such linkages provides insightful information for designing pro-poor growth strategy. For this purpose, a poverty–growth elasticity was calculated to enable direct comparison of the various poverty-reduction outcomes.[6] 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 simulated. The poverty–growth elasticities are endogenous outcomes from the model results. Growth affects individual households differently due to heterogeneity across household groups. As shown in above analysis, with different income sources, land size, and household characteristics, changes in income and consumption across households differ considerably from average changes at the national level (that is, per capita GDP). To capture growth–poverty linkages, changes in the distribution of incomes, which are primarily determined by a country's initial conditions, need to be understood. For example, households with greater opportunities to produce

[6]The poverty–growth elasticity used in this study measures the responsiveness of the poverty rate to changes in the per capita GDP growth rate. The formula for this elasticity is shown below:

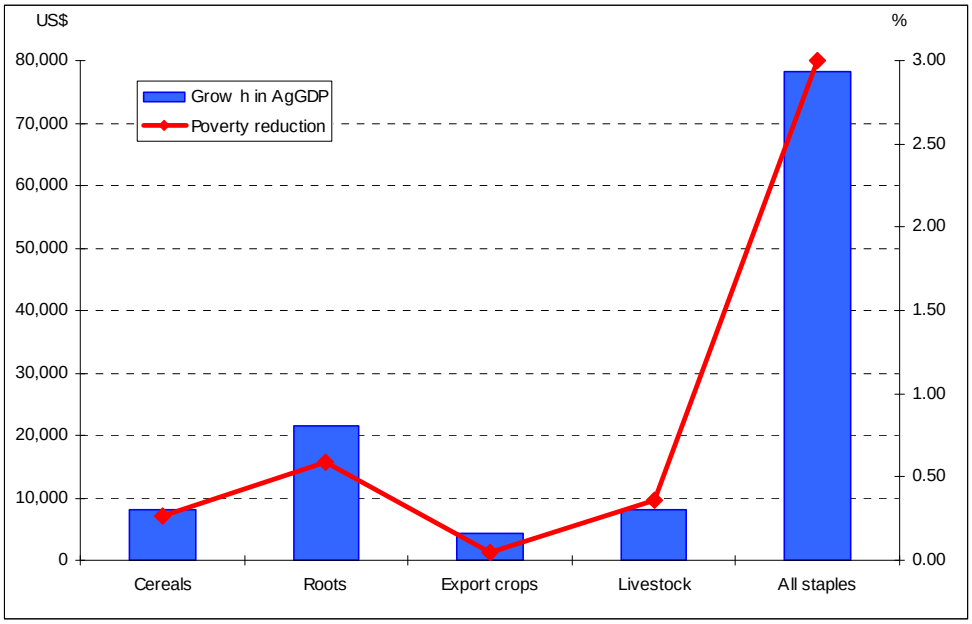
$$\frac{\Delta P0/P0}{\Delta GDPpc/GDPpc} = \frac{\Delta P0}{\Delta GDPpc} \cdot \frac{GDPpc}{P0},$$

where $\Delta P0$ and $\Delta GDPpc$ are average annual changes (from the base-year) in the poverty headcount rate and level of per capita GDP; and $P0$ and $GDPpc$ are the base-year poverty headcount rate and per capita GDP. The poverty–growth elasticity measures the percentage change in the poverty headcount rate caused by a 1 percent increase in per capita GDP. This is *not* equivalent to a percentage point change in the poverty headcount rate.

higher value export agricultural products may be better positioned to benefit from export agriculture, but since households involved in export crops are usually less remote and less poor, economic growth driven by agricultural exports may in fact have less of an impact on poverty. In contrast, staple crops are a more important source of agricultural incomes in the poorer (and more remote) regions of the country. Hence, because staples have a greater impact as an income source for the poor, growth in the production of staple crops is expected to be more pro-poor than growth in the production of agricultural exports.

A large gap between the poverty–growth elasticities between staples and agricultural exports indicates the importance of growth of staples for poorer rural households (Table 17). If economywide growth is led by growth in staple crops and livestock (Scenario 20), a 1 percent growth in per capita GDP leads to a 1.3 percent decline in the national and rural poverty rate. However, if economywide growth is led by traditional agricultural export growth (Scenario 16), a 1 percent growth in per capita GDP only reduces the national poverty rate by 0.85 and the rural poverty rate by 0.87 percent, (Table 17).

Figure 5. Increases in Agricultural GDP and Decreases in Rate of Rural Poverty by 2015, Based on a 1 Percent Increase in Annual Growth by Commodity Group



Source: Model simulation results.

Table 17. Poverty Reduction–Growth Elasticity

Scenario	Poverty reduction–growth elasticity	
	National	Rural
Staple-led growth (Scenario 21)	–1.30	–1.31
Cereal-led growth (Scenario 4)	–1.22	–1.23
Maize-led growth (Scenario 1)	–1.70	–1.70
Rice-led growth (Scenario 2)	–0.49	–0.50
Wheat-led growth (Scenario 3)	–0.83	–0.83
Root-led growth (Scenario 8)	–1.56	–1.58
Cassava-led growth (Scenario 5)	–1.56	–1.50
Potato-led growth (Scenario 6)	–1.50	–1.53
Sweet potato-led growth (Scenario 7)	–2.26	–2.32
Banana-led growth (Scenario 9)	–1.03	–1.05
Pulses and oilseed-led growth (Scenario 12)	–2.36	–2.36
Bean-led growth (Scenario 10)	–2.37	–2.36
Soybean-led growth (Scenario 11)	–2.16	–2.20
Livestock-led growth (Scenario 20)	–1.05	–1.07
Poultry and egg-led growth (Scenario 17)	–1.33	–1.35
Other meat and milk-led growth (Scenario 18)	–0.98	–1.00
Export crop-led growth (Scenario 16)	–0.85	–0.87
Coffee-led growth (Scenario 13)	–1.45	–1.49
Tea-led growth (Scenario 14)	–0.33	–0.34
Pyrethrum-led growth (Scenario 15)	–2.97	–3.05
Agriculture-led growth (Scenario 22)	–1.16	–1.18

Source: Model simulation results.
Note: Percentage reduction in poverty rate is based on 1 percent GDP per capita growth led by a specific agricultural sub-sector.

Sources of Income Growth and Poverty Reduction

Rwandan agriculture is dominated by the production of root crops and bananas, which together account for one-third of the country's agricultural GDP and food consumption. National growth targets are only available for two root crops—potatoes and cassava; hence, as previously mentioned, targets for sweet potatoes and bananas were estimated at about a 3.5 percent yield growth. Growth in these four crops results in 3.27 percent per year growth in root crops as a whole from 2006 to 2015 under Scenario 23 (Table 16, part 3). While roots crops and bananas still contribute the largest share of AgGDP, the modest growth under this scenario only results in 7.2 percent AgGDP growth and 3.4 percent of total GDP growth (Table 18).

Table 18. Sources of Income Growth and Poverty Reduction in the Model

Indicator	Non-agriculture	Agriculture	*Agriculture*					
			Staple crops & livestock	*Staple crops*				
				Cereals	Roots & bananas	Pulses &oilseeds	Livestock	Export crops
Contribution to growth (total is 100)								
GDP	49.9	50.1	35.0	14.3	3.4	3.1	14.2	15.1
AgGDP	2.7	97.3	69.2	30.1	7.2	6.9	25.1	28.1
Income for different rural household groups								
With cash crops	33.7	66.3	45.1	19.3	4.5	4.1	17.2	21.2
Without cash crops (10 percent of rural households)	48.5	51.5	45.6	26.3	4.3	7.4	7.6	5.9
Male-headed households	32.1	67.9	45.5	19.1	4.4	4.1	18.0	22.3
Female-headed households	38.7	61.3	45.8	19.7	4.5	4.5	17.1	15.5
Rural Group 1	27.9	72.1	52.4	27.7	6.0	5.2	13.6	19.7
Rural Group 2	32.6	67.4	43.9	20.6	4.6	4.1	14.6	23.5
Rural Group 3	35.3	64.7	45.0	16.9	4.0	4.0	20.1	19.8
Contribution to poverty reduction (total is 100)								
National	39.4	60.6	40.2	11.5	4.2	9.6	15.0	20.4
Rural	37.0	63.0	41.6	11.8	4.4	9.8	15.6	21.4
Income for different rural household groups								
With cash crop	36.7	63.3	40.9	11.2	4.3	9.3	16.0	22.4
Without cash crop (10 percent of rural)	41.1	58.9	51.5	19.5	6.0	16.1	9.9	7.3
Male-headed households	36.5	63.5	40.9	12.1	2.9	9.4	16.5	22.6
Female-headed households	38.3	61.7	43.2	11.0	8.2	10.7	13.3	18.5
Rural Group 1	33.2	66.8	46.6	18.7	6.0	9.8	12.1	20.2
Rural Group 2	42.4	57.6	35.8	7.5	2.3	10.3	15.7	21.8
Rural Group 3	34.3	65.7	42.9	8.1	5.1	8.9	20.9	22.8

Source: Model simulation results.

Note: Results of growth Scenario 23.

Disaggregated results for the root crops (and bananas) are provided in Table 19. For example, AgGDP grows at 3.63–3.64 percent (Table 19, column 2) when cassava production increases at 2.79 percent per year or sweet potato production grows at 2.14 percent per year (Table 19, column 1). This represents a 0.03–0.04 percent increase over baseline levels. The change in AgGDP in 2015, which is valued at US$2.4 and US$3.4 million, respectively, for these two crops (Table 19, column 4), is comparable under both scenarios (Table 19, column 6), but the growth elasticity is different (Table 19, column 7). For cassava, growth elasticity is 0.04, while for sweet potatoes it is 0.06. Bananas, by comparison, have the highest AgGDP growth elasticity, at 0.14, because of the comparative size of this subsector.

Cereal production is a relatively small subsector in Rwanda's economy, currently accounting for 10 percent of AgGDP. Nevertheless, national growth targets for maize and rice are very high (see Table 14), so total grain production grows at 9.62 percent per year from 2005 to 2015 under Scenario 23 (Table 16, part 3). As a result, cereals contribute 30.1 percent of AgGDP growth and 14.3 percent of total GDP growth under this scenario, which is three times the baseline level (Table 18).

Livestock currently represents about 15 percent of AgGDP, but national growth targets for poultry, eggs, and milk are very high (combined with comparatively modest targets for beef, other meat, and fish; Table 14). On this basis, livestock production under Scenario 23 grows at 7.82 percent per year between 2006 and 2015 (Table 16, part 3), which is 3.6 percent higher than baseline levels. So despite its relatively small overall size, the livestock subsector is an important prospective contributor to AgGDP growth (approximately 25 percent) and total GDP growth (14 percent).

Three main export crops—tea, coffee and pyrethrum—account for only 7 percent of AgGDP, but they are a strong source of foreign exchange earnings. Consequently, very high national growth targets have been set for all three of these crops, resulting in a total production growth rate of 9.93 percent per year between 2006 and 2015 (Table 16, part 3). While no targets have been set for nontraditional export commodities, such as fruit and vegetables, production of these commodities has grown rapidly in recent years, so a

Table 19. Sources of Overall Growth by Different Agricultural Subsectors

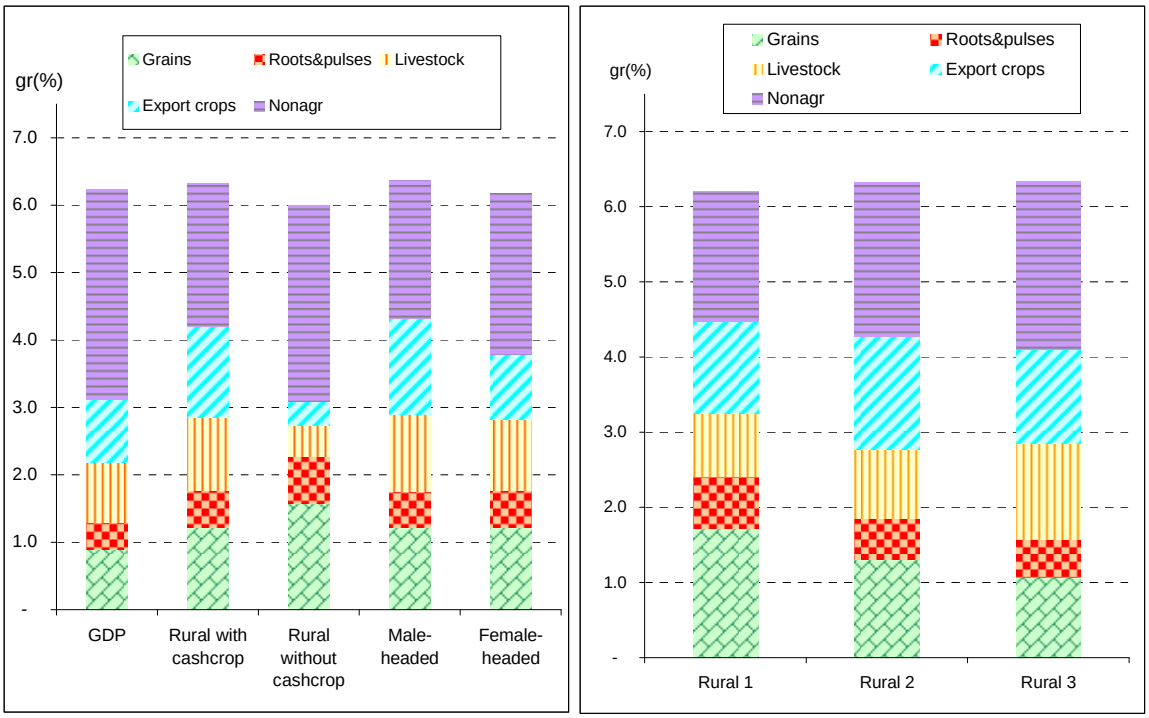
Scenarios	Annual growth based on sector output, 2005–15 (%)	Annual growth in AgGDP 2005–15 (%)	Increase in GDP by 2015 (million US$)	Increase in AgGDP by 2015 (million US$)	Change in AgGDP from baseline 2015	Change in output from baseline 2015	AgGDP growth elasticity
	(1)	(2)	(3)	(4)	(5) = (3)/ 2015 AgGDP	(6) = (4)/ 2015 output	(7) = (5)/(6)
Maize-led growth (Scenario 1)	8.09	3.78	13,468	13,259	0.02	0.38	0.05
Rice-led growth (Scenario 2)	13.05	4.15	42,242	41,914	0.05	0.74	0.07
Wheat-led growth (Scenario 3)	7.97	3.70	7,153	7,617	0.01	0.32	0.03
Cassava-led growth (Scenario 5)	2.79	3.63	2,361	2,365	0.00	0.08	0.04
Potato-led growth (Scenario 6)	5.31	3.67	5,505	5,257	0.01	0.13	0.05
Sweet potato-led growth (Scenario 7)	2.14	3.64	3,388	3,396	0.00	0.08	0.06
Banana-led growth (Scenario 9)	4.32	3.65	3,698	3,668	0.00	0.03	0.14
Soybean-led growth (Scenario 11)	6.75	3.64	3,118	3,199	0.00	0.51	0.01
Bean-led growth (Scenario 10)	2.84	3.74	10,493	10,971	0.01	0.16	0.09
Coffee-led growth (Scenario 13)	13.06	3.84	24,053	18,420	0.02	2.02	0.01
Tea-led growth (Scenario 14)	12.41	4.00	31,286	30,142	0.04	1.85	0.02
Pyrethrum-led growth (Scenario 15)	20.36	3.64	4,636	2,973	0.00	1.88	0.00
Poultry and egg-led growth (Scenario 17)	18.47	3.82	16,971	16,774	0.02	2.97	0.01
Other meat/milk-led growth (Scenario 18)	6.11	4.02	39,630	31,884	0.04	0.71	0.06

Source: Model simulation results.
Note: Results of Scenarios 1–3, 5– 7, 9–11, 13–15, and 17– 19.

growth rate of more than 6 percent per year is assumed in the model. The combined growth of both traditional and nontraditional exports under Scenario 23 results in 28.1 percent AgGDP growth and 15.1 percent total GDP growth, making export crops the second-largest contributor to overall growth.

Nevertheless, the associated contributions to income growth vary across rural household groups (Table 18 and Figure 6). As previously discussed, grain growth is mainly important for rural households that do not grow cash crops and those with the smallest landholdings (Rural Group 1). For these groups, 26.3 and 27.7 percent of their income growth, respectively, can be attributed to cereal growth under Scenario 23. Export crops, including both traditional and nontraditional exports, are the most important source of income growth for the households that grow cash crops, male-headed households, and households with medium-sized landholdings (Rural Group 2). Export growth for all three household groups accounts for more than 20 percent of income growth, whereas for female-headed households, export crops account for 15.5 percent of income growth. Livestock growth, however, appears to be equally important for income growth in both male- and female-headed households, contributing between 17.1 and 18.0 percent of income growth under Scenario 23.

Figure 6. Sources of Growth by Household Group



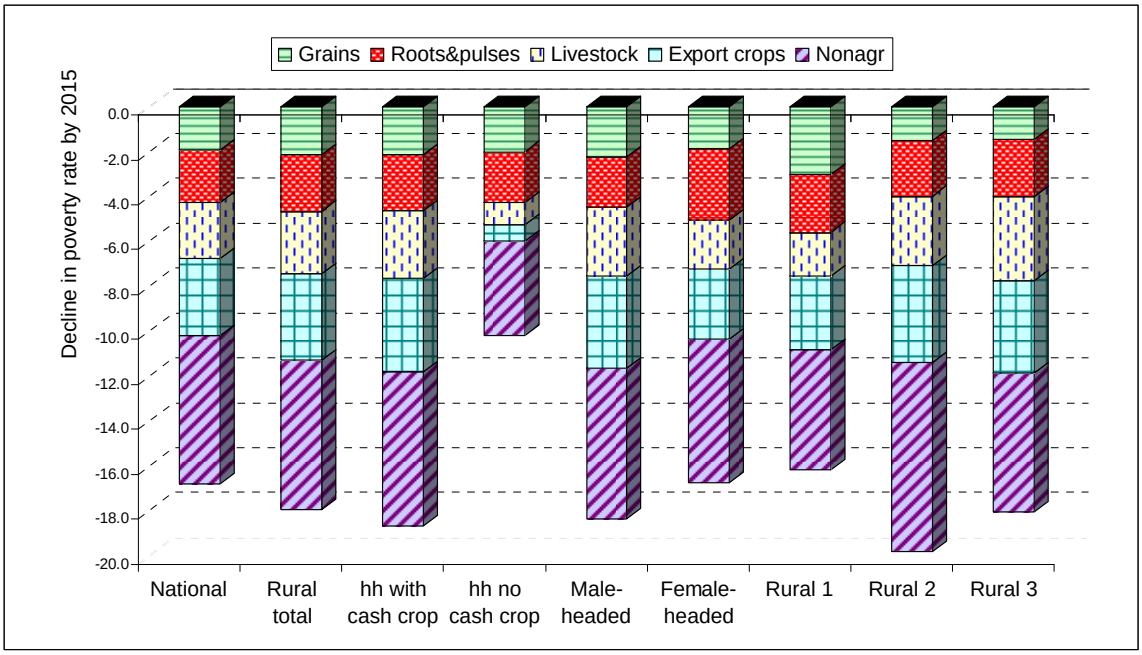
Source: Model simulation results.

Looking at overall poverty-reduction effects, based on 6 percent annual growth in both agricultural and nonagricultural sectors, agricultural growth is more important at both the national and household group levels (Table 18 and Figure 7). While agriculture contributes 50 percent of total GDP growth, it also contributes over 60 percent of the reduction in the national poverty rate.

Within agriculture, staple crop and livestock growth is the dominant source of poverty reduction across all types of households, contributing in average 42 percent of poverty reduction in the rural, ranging from 36 percent for rural group 2, to 52 percent for the group of households with cash crop production (Table 18). As already discussed, the grain sector is important to income growth for the household groups without cash crop (contributing 26.3 percent of increases in their income). However, it less important to reducing poverty for these households, as growth in grains accounts for 19.5 percent of the reduction in poverty among these households. While livestock contribute roughly equally to poverty reduction and income growth across all household groups, the role of

pulses and oilseeds in the poverty reduction rises in comparison with its role in income growth for almost all household groups. For example, Growth in pulses and oilseeds, for example, accounts for 8.9–10.3 percent of the poverty reduction in the three rural groups, while it accounts for 4.0–5.2 percent of the income increases. When nontraditional exports are taken into account, export crops become an important contributor to poverty reduction for households that derive a dominant share of their income from export crops.

Figure 7. Sources of Poverty Reduction by Household Group



Source: Model simulation results.

Improved Food Security

Rwanda depends on imports for many food commodities. For example, 30 percent of rice and 60 percent of wheat in domestic markets are imported. Grain imports totaled 44,000 tons in 2003, comprising 50 percent wheat, 30 percent rice, and 20 percent maize (Table 20, column 2). MINECOFIN (2005) estimated that national of milk and egg production can only meet 39 and 10 percent of domestic needs, respectively. The gap between supply and demand illustrates the need for the country to raise the productivity levels of many of its agricultural subsectors. The domestic supply of grains and livestock products will need to increase significantly if national growth targets for maize, rice,

wheat, milk, and poultry are to be met. Domestic supply will meet with domestic demand for rice and milk without imports by 2015 as growth target in rice and milk production is set at very high, but maize and wheat still need to depend on imports. Wheat imports currently account for almost two-thirds of domestic demand, and under Scenario 23 they fall to less than half of domestic demand in 2015 (Table 20).

Table 20. Imports of Agricultural Products in Simulations

	Base year 2003		Growth simulation Scenario 23		
Commodity	**Production (000 metric tons)**	**Imports**	**Projected production in 2015**	**Projected imports in 2015**	**Import annual growth rate 2005–15 (percent)**
Maize	81	11	189	42	15.0
Rice	28	13	108	0	—
Wheat	15	20	36	30	3.9
Beans	258	15	367	96	16.7
Vegetable oil	1	6	2	9	3.0
Sugar	7	11	15	20	5.7
Milk	129	3	323	0	—
Industry (US$ million)	286	100	552	124	1.9

Source: Model simulation results.

Rice, wheat, and livestock products are income-elastic and growth in their demand is driven not only by population growth but also by increased income. With income generated from growth in grains, livestock, and other agricultural production, per capita rice and wheat demand increase significantly. Per capita rice demand increases from 5.2 kilograms in 2003 to 9.9 kilograms in 2015, or at 6.7 percent per year, while wheat demand increases from 4.5 kilograms in 2003 to 6.0 kilograms by 2015, or at 3.1 percent per year (Table 21). In the case of maize, increased imports are actually the result of rapid growth in poultry and other livestock, which stimulates demand for maize as feed. The food demand growth rate for maize is only 3.2 percent, while the production demand growth rate is 8.1 percent. Thus, even though maize production significantly increases, domestic production still cannot meet increased demand.

Demand for root crops in Rwanda is largely met by domestic production; hence, the model assumes balanced growth in supply and demand in the base year. Targeted

growth for cassava is modest, comprising a 2.9 percent expansion in area per year and no yield growth (Table 21). National targets involve high yield growth for potatoes and modest area expansion, which leads to 5.4 percent of annual growth in the production between 2005 and 2015. The model captures certain negative price effects because growth in potato production outpaces increased demand; hence, the endogenous production growth rate of 5.4 percent is much slower than the growth target set by the government. Lack of direct consumption demand will constrain the growth in sweet potato production, which is 2.3 percent annually, and per capita consumption of this commodity actually falls. Bananas production grows at 4.5 percent, while per capita consumption grows at 2.0 percent (Table 21).

While Rwanda depends on bean imports for domestic consumption, no clearly defined growth target has been set. With assumed additional growth of 3.5 percent per year, bean imports still increase, which indicates that it has high income elasticity (Table 20). In the base year, bean imports represent 5 percent of domestic demand. Under Scenario 23, bean imports rise to 96,000 tons in 2015, but domestic production also increases to 370,000 tons.

Rwanda is self sufficient in producing livestock products, with the exception of milk. Under Scenario 23, milk production grows at 8.6 percent annually between 2005 and 2015, such that import substitution is achieved before 2015. Nevertheless, milk is very income-elastic, and per capita demand grows at 5.7 percent per year.

National targets for growth in egg and poultry production are also very high. While both poultry and eggs also have very high income elasticity, the prices of these two commodities fall over time due to extremely high production growth. Per capita demand grows at 7.6 percent per year for poultry, and 10.9 percent for eggs between 2005 and 2015 (Table 21). This benefits consumers but possibly has negative effects for producers.[7] Per capita growth is around 2.2 percent for other meat demand, while targeted growth in total production is about 5 percent (Table 21). Thus, supply and demand for meat products other than poultry appear to maintain balanced growth to 2015.

[7] Price effects are discussed further in the next section.

Table 21. Growth Rate in Total Production and Per Capita Demand

Commodity	Projected annual growth rate in production (2005–15)	Projected annual growth rate in per capita demand (2005–15)
Maize	8.1	3.2
Rice	13.2	6.7
Sorghum	3.3	0.2
Wheat	7.9	3.1
Cassava	2.9	–0.2
Potatoes	5.4	2.7
Sweet potatoes	2.3	–0.9
Other roots	2.5	–0.5
Bananas	4.5	2.0
Beans	3.3	2.2
Peas	3.7	2.3
Peanuts	3.6	0.9
Soybeans	7.0	0.1
Vegetable oil	5.5	3.0
Vegetables	7.4	4.3
Fruits	6.6	3.8
Sugar	6.7	3.4
Coffee	8.8	3.3
Tea	9.9	3.2
Pyrethrum	22.4	—
Beverage	4.3	1.5
Beef	4.9	2.2
Mutton	5.0	2.2
Poultry	10.5	7.6
Other meat	4.9	2.1
Fish	6.2	3.4
Egg	13.9	10.9
Milk	8.6	5.7
Home processed food	4.3	1.5
Hides/skins	4.9	—
Industry	6.0	3.3
Services	6.5	3.7

Source: Model simulation results.
Note: Results of Scenario 23.

Growth in Agricultural Exports Helps Reduce Trade Deficits

Growth in the three major agricultural export products—coffee, tea, and pyrethrum—along with hides/skins, the fourth major traditional export commodity, aligns with national targets. For coffee, the growth rate is 8.8 percent per year from 2005 to

2010 and 10.1 percent from 2010 to 2015; for tea, the growth rates are 9.9 and 12.0 percent for the two periods; and for pyrethrum the growth rates are 22.4 and 26.5 percent. As previously mentioned, hides/skins are treated as a byproduct of animal production, so the assumed growth rate matches the rate for beef and mutton (5 percent). Based on these rates, exports of these four products grow rapidly (Table 22).

Table 22. Agricultural Export Growth under Scenario 23

Growth rate/commodity	Production	Exports
Annual growth rate, 2005–15 (%)		
Coffee	8.8	8.9
Tea	9.9	10.1
Pyrethrum	22.4	22.4
Hides	4.9	4.9
Annual growth rate (%)		
Agricultural exports		9.9
Agricultural imports		5.3
Agricultural trade surpluses		
Agricultural trade surpluses in the base year (US$ millions)		14.89
Agricultural trade surpluses by 2015 (US$ millions)		66.35

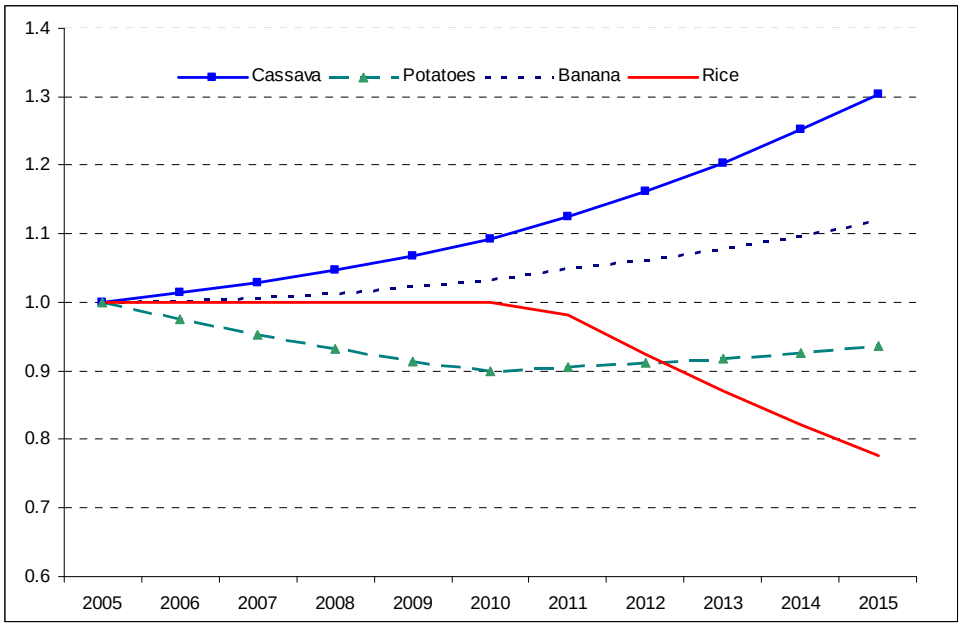
Source: Model simulation results.

Rwanda heavily depends on agriculture for export earnings. Agricultural trade surpluses were about US$15 million in the base year. Under Scenario 23, total growth of (traditional and nontraditional) agricultural exports is 9.9 percent and growth of agricultural imports is 5.3 percent per year. Thus, the agricultural trade surplus increases to more than $US66 million by 2015 under Scenario 23, more than four times the baseline level (Table 22). Under national targets, exports of washed coffee are projected to increase, while those of green coffee are projected to decrease. Washed coffee currently accounts for 3 percent of total coffee exports. Since the price of washed coffee is about 60 percent higher than the price of green coffee, an increase in the share of washed coffee to 60 percent of total coffee exports is equivalent to raising average export prices by 3 percent annually between 2006 and 2015. The model indicates that this scenario results in an increase of US$55 million exports by 2015, raising the agricultural trade surplus to more than US$100 million.

Possible Declines in Agricultural Prices

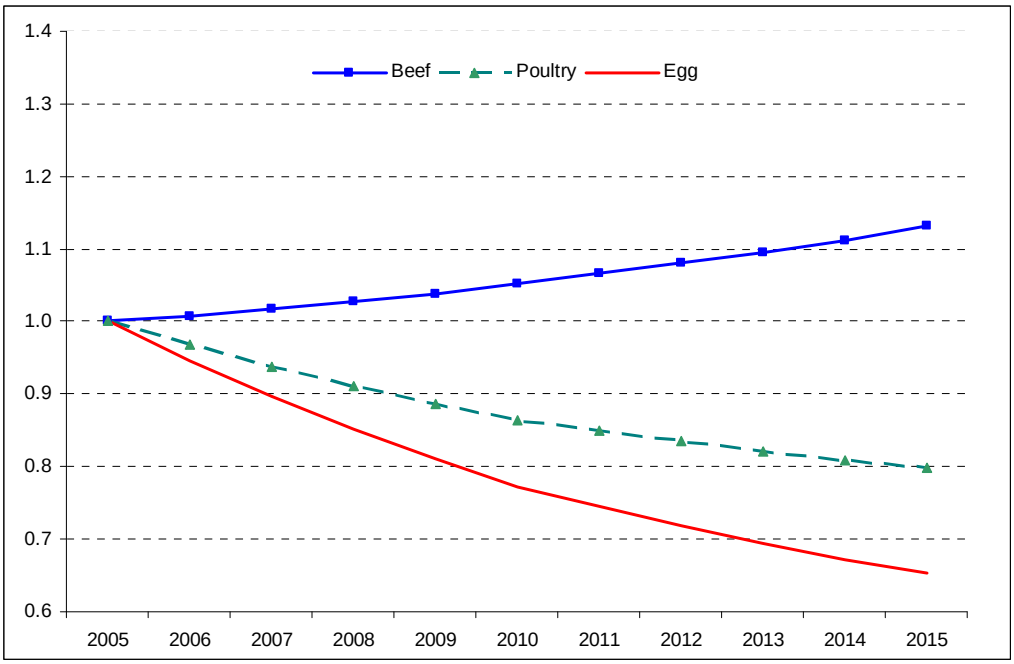
Growth does not always benefit producers, especially when it is unbalanced and if it only occurs in a few agricultural subsectors. Targeted growth of rice, potatoes, poultry, and eggs is very high, and if growth is too high compared with other agricultural subsectors and the nonagricultural sector, negative price effects could result (Figures 8 and 9). Under Scenario 23, the price of rice falls by more than 20 percent, which benefits consumers but is harmful to rice farmers. With annual growth of 5.4 percent between 2006 and 2015, the price of potatoes also falls (by about 10 percent). Exploring potato market opportunities, such as potato processing or exports, could help to reverse these trends. In the livestock sector, 10.5 and 13.9 percent of Annual 10.5 percent growth of poultry production and 13.9 percent growth in egg production between 2006 and 2015 also cause prices for these commodities to decline, even though their demand is highly income-elastic (Figure 9).

Figure 8. Relative Prices for Selected Crops



Source: Model simulation results.
Note: Base year equals 1.0.

Figure 9. Relative Prices for Selected Livestock Products

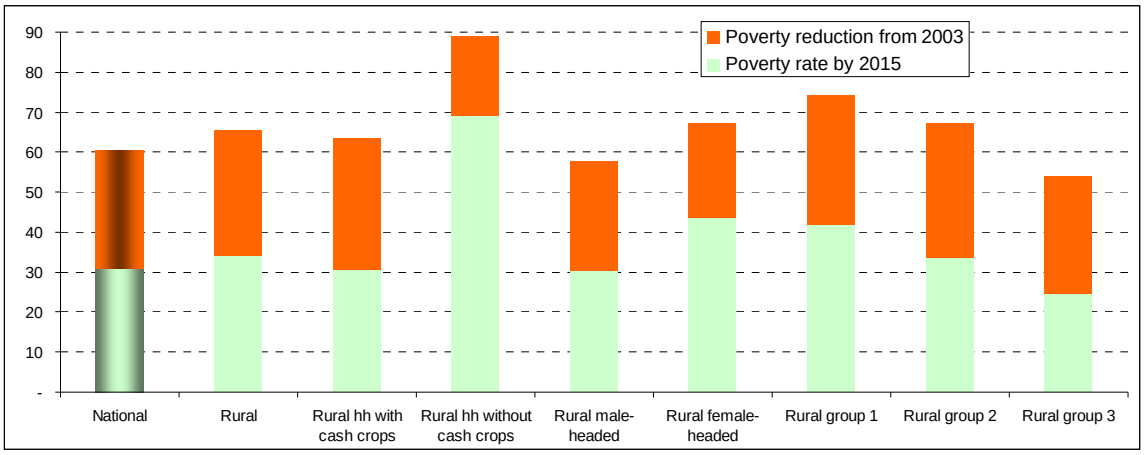


Source: Model simulation results.
Note: Base year equals 1.0.

V. HALVING POVERTY REQUIRES A GROWTH RATE OF NINE PERCENT IN AGRICULTURAL GDP

The model also supports an evaluation of the growth rate needed to meet the Millennium Development Goal of halving the national poverty rate by 2015. As was discussed in the previous section, the combination of agricultural subsector growth targets will allow Rwanda to meet the 6 percent AgGDP growth target set by CAADP. Combined with targeted nonagricultural growth, this strategy will significantly reduce poverty, but it will not be enough to reach the goal of halving poverty by 2015. Targeted growth in some agricultural subsectors and modest growth in others does not generate sufficient poverty-reduction effects. For this reason, another scenario is explored that assumes more aggressive growth in those agricultural subsectors that as yet do not have established national targets. In additional, more rapid growth is assumed for the nonagricultural sector. These assumptions, combined with the national growth targets for other agricultural subsectors discussed above, result in 9 percent annual AgGDP growth and 7.2 percent nonagricultural GDP growth between 2006 and 2015. On this basis, GDP grows at 8 percent annually for the period, sufficient to enable Rwanda to meet the goal halving the national poverty rate by 2015 (Figure 10).

Figure 10. Poverty Reduction under the Millennium Development Goal Scenario



Source: Model simulation results.
Note: Scenario simulates AgGDP growth of 9.0 percent, nonagGDP growth of 7.2 percent, and GDP growth of 8.0 percent

Nevertheless, even with this high national growth, and even if the national poverty goal is met, model simulations indicate that poverty reduction would still be modest among some household groups, especially those with high initial poverty rates (that is, the poorest). For example, for the group of households with more land (Rural Group 3), the poverty rate is more than halved by 2015 from its current, relatively low, level. For those households with less land, however, (Rural Group 1) the poverty rate is reduced by 40 percent from its current high level of 74 percent. And for rural households that do not grow cash crops, the average poverty rate is cut by only 20 percent, from an extremely high initial level of 89 percent—hence, the poverty rate among this group remains as high as 70 percent in 2015. Finally, the average poverty rate for rural female-headed households remains as high as 44 percent by 2015, 24 percent lower than the current rate.

Obviously, more targeted growth and poverty reduction policies are necessary if the majority of rural households are to share in growth gains. For landless households to participate in high-value agricultural production, increasing nonfarm employment opportunities would appear to be more important. For rural household with female heads, noneconomic factors need to be addressed to remove constraints to participation in the welfare effects of economic growth.

VI. AGRICULTURAL SPENDING REQUIRED TO ACHIEVE CAADP AND POVERTY REDUCTION GOALS

Achieving the growth required in the Rwanda's agricultural sector for meeting both CAADP and poverty reduction goals is 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 under various scenarios.

The previous analysis indicates that agricultural GDP could grow at more than 6 percent annually in the next 10 years if agricultural commodity or subsector growth can be achieved to reach national targets set up by the governments. These growth targets are also consistent with CAADP goals and will significantly reduce poverty. However, meeting the goal of halving poverty by 2015 will require an annual growth rate of 9 percent between 2006 and 2015.

To promote 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. For example, three types of investment programs are currently being implemented for marshland development, and, among which the national rice development program is estimated to be valued at about 330 million RWF. Many development strategies targeting sectoral productivity, production capacity, commodity quality, and competitiveness are underway. 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.

While all these interventions and investments will build a solid foundation for higher agricultural growth in the future, the short implementation period makes quantitative assessment of the impacts of these endeavors on future growth difficult. The timeframe also makes it impossible to assess and compare the impacts of different types

of investments. For this reason, this analysis focuses on aggregate public investment in agriculture and the amount of investment required to reach the growth targets discussed in the previous sections.

Current Agricultural Spending Trends

Published data in the Annual Finance Laws, 1999–2006 (MINECOFIN 2006) shows that the share of public resources allocated to the agricultural sector has declined in Rwanda, even though the absolute value in current terms has increased modestly. The share of government spending allocated to agriculture fell to less than 4 percent in recent years, compared with levels as high as 8.6 percent in 2002 (Table 23). While the government's total spending grew more than 10 percent from 2001 to 2006, the growth rate of agricultural spending (in real terms) is negative for this period. The share of agricultural funding allocated to development is relatively high, averaging more than 12.3 percent per year during 2000–06, vs. 5.2 percent of agricultural spending on average in total national budget during this period. Nevertheless, even in this case, the share of resources allocated to agriculture has declined, from an average of 16 percent in the early 2000s to less than 10 percent in recent years.

Estimated Spending Required for Agricultural Growth

How much agricultural spending is really required to achieve CAADP and poverty reduction goals? This analysis utilizes a two-step approach in answering this question. The first step is to estimate the agricultural growth required to achieve development objectives using the so-called "poverty reduction elasticity." For example, to achieve the MDG One, it would require an annual growth rate of 9 percent in the agricultural sector. The second step involves estimating the required agricultural spending to achieve the required agricultural growth targets. This relationship is termed "agricultural growth elasticity," and it can be estimated econometrically using historical data. For the purposes of this study, recent national data were used.

Table 23. Economic Growth and Government Budget Allocation

Indicator	1999	2000	2001	2002	2003	2004[a]	2005[a]	2006	Growth rate (percent)
1999 constant RWF (billions)									
AgGDP	270	283	295	330	333	339	359		4.2
Non-AgGDP	375	400	434	468	473	499	532		4.8
GDP	645	684	730	798	805	838	890		4.6
Agricultural spending			11.1	12.6	8.7	10.5	8.9	8.3	–6.5
Agricultural development spending	14.6	6.5	10.4	6.7	6.6	7.8	5.6	5.4	–5.8
Nonagricultural spending			168	134	215	249	250	244	11.8
Total spending	174	124	179	146	224	260	258	252	10.8
Total development spending	77	64	55	55	58	69	77	69	4.2
Ratio to GDP or total spending (%)									
Agricultural spending/total spending			6.2	8.6	3.9	4.0	3.4	3.3	
Agricultural spending/AgGDP			3.8	3.8	2.6	3.1	2.5		
Agricultural development spending/total development spending	19.0	10.2	18.9	12.3	11.4	11.4	7.2	7.8	
Nonagricultural spending/non-AgGDP			23.0	16.8	26.8	29.8	28.0		
Total spending/GDP	27.0	18.1	24.5	18.3	27.8	31.0	29.0		

Source: Annual Finance Laws 1999–2006 Government of Rwanda.
[a.] *Values are author estimates.*

Needless to say, the impact of many investments on growth cannot be realized immediately; hence, a comparatively longer time series is needed to achieve a robust estimation. However, official national agricultural spending data are only available for 2001–06, so additional data (1995–2000) were drawn from the International Monetary Fund (IMF 2004)

The estimated elasticity of agricultural growth with respect to agricultural spending during 1995–2005 was 0.17—that is, for every 1 percent growth in agricultural spending, 0.17 percent AgGDP growth is resulted. This elasticity is much lower than the African average of 0.366 based on a cross-country estimation using a much longer data time series. Due to Rwanda's recent turmoil history before 1995, the estimated coefficient between agricultural spending and agricultural growth may not represent the true relationship in the future. Moreover, many investment projects were initiated only recently and their potential effects of agricultural growth cannot be captured in 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 24). Two sets of values are reported, corresponding to the two different agricultural growth scenarios (Scenario 23 and MDG scenario) discussed in the previous section. As discussed above, with 6.2 percent of annual growth in AgGDP, together with similar growth rate in the nonagricultural sector, total GDP will grow at 6.2 percent annually in the next 10 years in Scenario 23. Required agricultural spending under this scenario is reported under "CAADP target" (Table 24, columns 2 and 3). A 6.2 percent increase in AgGDP per year from 2006 to 2015 requires associated growth in agricultural investment (represented by the agricultural development funds) at 35.9 percent annually with the low elasticity and 18.4 percent with the high elasticity. Assuming that the government's allocation to nonagricultural sectors is proportional to nonagricultural GDP, and agricultural nondevelopment spending proportional to AgGDP, the total government budget is estimated to grow at 6.7 percent with high elasticity and at 8.2 percent with low elasticity. As agricultural spending grows much more rapidly than the total spending, the agricultural spending share will rise to 4.4 or 6.6 percent in 2010 and 6.5 or 17.6 percent in 2015. The lower number corresponds to high elasticity, while the higher number

corresponds to low elasticity (Table 24, columns 2 and 3). Obviously, whether the government will meet requirement of the Maputo declaration of allocating at least 10 percent of its total budget to agriculture depends on whether agricultural spending can stimulating agricultural growth efficiently. With (less efficient) low elasticity, the government needs to allocate 18 percent of its total budget to agriculture by 2015, while if spending has (more efficient) high elasticity, about 7 percent of the total government budget would be needed to support 6.2 percent annual agricultural growth.

As previously identified, 6 percent annual agricultural growth is insufficient for the country to meet the goal of halving national poverty by 2015; instead, 9 percent growth per year during 2006–15 is needed (MDG scenario). Estimates of the required spending to achieve this level of growth are provided in Table 24 (columns 4 and 5), indicating that agricultural spending needs to grow at the extremely high rate of 45.6 percent annually if the investment has a low growth elasticity, or 22.6 percent if the investment can be more efficient (that is, with a high elasticity). Assuming the growth in nonagricultural spending is proportional to nonagricultural GDP and agricultural nondevelopment spending is proportional to AgGDP, the total government budget would grow at 8.3 or 12.2 percent annually, depending on whether the elasticity was high or low. The share of agricultural spending would rise to 5.2–9.2 percent in 2010 and 10.0–34.5 percent in 2015, again, based on high or low elasticity. While this 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 experiences in many Asian countries in their early stages of development.

Table 24. Estimated Resource Allocation to the Agricultural Sector

Indicator	Current (2001–06) (1)	CAADP target Low-elasticity (2)	CAADP target High-elasticity (3)	Millennium Development Goal 1 Low-elasticity (4)	Millennium Development Goal 1 High-elasticity (5)
Growth rate (%)					
AgGDP	4.2	6.2	6.2	8.8	8.8
Non-AgGDP	4.8	6.2	6.2	7.2	7.2
GDP	4.6	6.2	6.2	8.0	8.0
Agricultural spending	–6.5	30.3	15.2	45.6	22.6
Agricultural development spending	–5.8	35.9	18.4	52.3	26.8
Nonagricultural spending	11.8	6.3	6.3	7.4	7.4
Total spending	10.8	8.2	6.7	12.2	8.3
Agricultural spending/total spending (%)	4.92				
2010		6.6	4.4	9.2	5.2
2015		17.6	6.5	34.5	10.0
Agricultural spending/AgGDP (%)	3.2				
2010		4.7	3.0	6.3	3.5
2015		14.1	4.6	30.7	6.5
		2015		2015	
Nonagricultural spending/nonagGDP (%)	24.9	44.1	44.1	44.1	44.1
Total spending/GDP (%)	26.1	32.1	28.3	38.3	27.9

Source: Estimated by the authors.

Identifying Investment Priorities

Estimating the public resources needed to reach particular agricultural targets is important, but prioritizing investments is equally important. Due to lack of data, this study is unable to analyze investment priorities based on their potential returns to agricultural growth and poverty reduction. This section only attempted to offer an indicative guide to the key investments to promote higher agricultural growth and rural poverty reduction in advance of more formal, rigorous analysis.

Research and Development (R&D), and Agricultural Extension

To increase production, reduce production costs and protect the environment, Rwandan farmers need improved technologies to increase yields, manage water, and use natural resources sustainably. IFPRI research on Uganda confirms that investment in agricultural R&D offers the greatest potential for enhancing productivity and reducing poverty (Fan, Zhang, and Rao 2004). Similarly, Thirtle, Lin, and Piesse (2003) showed that for every 1 percent increase in yield brought about by investments in agricultural R&D, two million Africans can be lifted out of poverty. However, agricultural research spending has declined in Rwanda in recent years. The 2006 budget allocated RWF1.5 billion for agricultural research, which accounts for only 0.3 percent of AgGDP. This is lower than the African average of 0.5–0.6 percent and much lower than 1 percent recommended by the World Bank. Rwanda must reverse this trend.

Irrigation

The success of the Asian Green Revolution in the 1960s and 1970s was built on rapid expansion of irrigated areas. In contrast to many other African countries, Rwanda has tremendous potential to expand its irrigation to more crop land, given its abundant rainfall and vast marshland. Private investment is still embryonic and requires leverage from public investment. The recent budget allocation to irrigation and marshland development has increased with the aim of expanding irrigated areas to 15 percent of crop land by 2015. It remains to be seen whether this allocation will be sufficient to reach

the target, and even the 15 percent target is still far below the Asia level of 30–50 percent.

Transportation Infrastructure

Rwanda has a sparse road system compared with other African countries, so farmers lack access to affordable, yield-enhancing inputs and inexpensive marketing channels. IFPRI studies for countries as diverse as Ethiopia, Ghana, Uganda, and Zambia emphasize the importance of rural roads for increasing smallholder access to agricultural inputs and product markets. Roads enable them to participate in higher value-added market chains, in turn significantly contributing to poverty reduction (Thurlow and Wobst 2004; Diao and Nin-Pratt 2005). Investment in rural feeder roads, in particular, can have large poverty reduction effects per unit of investment (Fan, Zhang, and Rao 2004). But the national target for road development is far too modest: road density is planned to increase from 0.54 to 0.56 kilometers per square kilometer during 2000–10 and 0.60 kilometers per square kilometer by 2020. These densities are far below the African average.

VII. SUMMARY OF MAJOR FINDINGS

To support various development initiatives in Rwanda, an economywide, multimarket (EMM) model was developed in this study to analyze the linkages and trade-offs between growth and poverty reduction goals at both macro- and micro-economic levels. An analysis was also conducted to calculate the required public resources in the agricultural sector for achieving various targets such as CAADP 6 percent annul agricultural growth and MDG One. The major conclusions are summarized below:

Six Percent Annual Growth of CAADP Goals is Achievable, but not Sufficient

The model simulations 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 2006 to 2015. With comparable growth in the nonagricultural sector, growth in the agricultural growth would increase to 6.17 percent and total GDP growth to 6.24 percent as a result of economywide interlinkages. Such growth would lead the national poverty rate to fall to 42.4 percent by 2015, a reduction of 17 percentage points over the 2005 rate. Nevertheless, this level of growth is still insufficient to enable Rwanda to achieve the Millennium Development Goal of halving the national poverty rate by 2015.

Growth Reduces Poverty Unevenly

The majority of rural households benefit from rapid agricultural growth, and the distribution of such benefits is comparatively equal. However, the most vulnerable households—those with very small landholdings (Rural Group 1), those headed by women, and those with few opportunities to participate in the production of cash crops—appear to benefit the least. For example, the rate of annual income growth for Rural Group 1 is 6.21, compared with 6.33–6.34 percent for the rural groups with more than 0.3 hectare of land. This lower income growth among vulnerable groups will increase the poverty gap among household groups. For example, under the simulations, the poverty rate for the rural female-headed households falls from 71.4 percent in 2005 to 54.7

percent by 2015, while the poverty rate for the rural male-headed households falls from 62.1 percent in 2005 to 43.6 percent by 2015, with more than 11 percent points of poverty gap between the two gender groups.

Subsector Level Growth Matters

Analysis of poverty–growth elasticity shows that 1 percent growth in per capita GDP, driven mainly by increased staple crops and livestock production, has a greater poverty-reduction effect than the same level of growth driven by export crops or nonagricultural sectors. 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 in reducing poverty.

Cereals, especially rice and maize, are among the high priorities for the government; accordingly, they have very high growth targets. If such growth target were reached, cereals would become the most important source of income growth for many rural households, especially for those with the smallest landholding. Growth in cereals would also help the country to reduce its dependence on imports. While rice would realize import substitution before 2015 based on current targets, maize would still need to be imported, because of the significantly greater feed demand caused by rapid growth in the livestock sector.

High growth in both traditional and nontraditional agricultural exports would significantly increase agricultural trade surpluses. The projected trade surplus would increase to more than $US66 million by 2015—four times its current level. If washed coffee (which has a much higher price that green coffee) reached a 60 percent share of total coffee exports, the value of exports would increase by US$55 million by 2015, raising the agricultural trade surplus to more than US$100 million.

The study 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 rice, potatoes, milk,

poultry, and eggs are very high, a negative price effect could result if production growth is out of balance with income growth. Simulations indicate that rice prices fall by more than 20 percent, which would benefit consumers but harm rice farmers. Potato prices also fall, indicating the need to explore other market opportunities in processing or exporting potatoes. In the livestock sector, of annual growth in poultry and egg production of 10.5 percent and 13.9 percent per year, respectively, during 2006–15 cause prices to decline for these two commodities, even though their demand is highly income-elastic.

Reaching MDG One Requires Substantially Higher and Balanced Growth

Analysis indicates that an agricultural growth rate of 9 percent from 2006 to 2015 will be necessary to meet the goal of halving the national poverty rate. Associated growth in GDP would be 8 percent. Still, even with such high growth and poverty targets, the poverty effects are still modest among some household groups, especially those with the highest initial rates of poverty. For example, for the group of rural household with smallest landholding (Rural Group 1), the poverty rate declines from 74 percent in 2003 to 42 percent by 2015. For the group of rural households that do not produce cash crops, the poverty rate is only cut by 20 percent by 2015, from the extremely high level of 89 percent in 2003. The average poverty rate for rural households headed by women remains as high as 44 percent by 2015, only 24 percent points lower than the current level.

Obviously, more targeted growth and poverty reduction policies are necessary to enable the majority of rural households to share in the benefits of economic growth. For households with the lowest landholdings (less than 0.3 hectare) participation in high-value agricultural production is unlikely, so a focus on increasing nonfarm employment opportunities would be more important for this group, and for the female-headed rural households, measures beyond economic policies are needed to overcome constraints to their participation in economic growth.

Agricultural Spending Needs to Increase Substantially

Meeting CAADP's 6 percent agricultural growth target will require the allocation of public resources to the agricultural sector to rise by between 6.5 and 17.6 percent by 2015, depending on efficiency in spending. This level of allocation translates, in real terms, as 15–30 percent annual growth in agricultural spending over the next 10 years. Given that agriculture needs to grow at as high as 9 percent to meet the goal of halving the national poverty rate by 2015, more rapid growth in agricultural spending is required. For reaching the MDG One, agricultural spending needs to grow at 22.6–45.6 percent per year and resources allocated to the agricultural sector need to reach 10.0–34.5 percent of the total government budget by 2015.

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APPENDIX TABLES

Table A1. Production Share in Total Agricultural Revenue, by Commodity and Household Groups

Household group	Maize	Rice	Sorghum	Wheat	Root crop	Bananas	Beans	Soybeans
National	3.3	4.1	2.0	2.0	17.5	11.6	7.2	0.7
For the poor	3.6	4.5	2.1	2.3	20.8	9.9	7.7	0.7
For the non-poor	3.2	4.0	2.0	1.9	15.9	13.0	7.1	0.6

Table A1. Continued.

Household group	Other pulses and oilseeds	Vegetables	Fruits	Three export crops	Other cash crops and processing food	Poultry and eggs	Other meats, milk, and fish
National	1.8	6.3	2.2	7.0	18.0	1.8	14.5
For the poor	1.2	7.3	2.4	9.2	16.1	1.6	10.5
For the non-poor	2.1	5.8	2.2	5.7	19.4	1.8	15.1

Source: Calculated by authors from the 1999–2001 EICV.

Note: Table indicates data used in the model.

Table A2. Consumption Share of Total Food Expenditure, by Commodity and Household Groups

Household group	Maize	Rice	Sorghum	Wheat	Root crop	Bananas	Beans	Soybeans
National	3.9	6.5	1.5	5.3	16.5	5.2	7.8	0.7
For the poor	5.6	2.7	2.1	4.9	24.4	5.3	11.7	1.0
For the nonpoor	3.0	8.4	1.3	5.5	12.7	5.1	6.0	0.6

Table A2. Continued.

Household group	Other pulses and oilseeds	Vegetables	Fruits	Three export crops	Other cash crops and processing food	Poultry and eggs	Other meats, milk, and fish
National	1.9	6.5	2.4	0.4	23.5	1.9	15.9
For the poor	1.8	9.9	3.3	0.1	19.5	0.8	6.9
For the nonpoor	2.0	4.9	1.9	0.5	25.5	2.3	20.2

Source: Calculated by authors from the 1999–2001 EICV.

Note: Table indicates data used in the model.

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