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Ministry of Agriculture, Livestock and Forestry

MINAGRI

Research Report

Forces Driving Change in Rwandan Smallholder Agriculture

1990-2001

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I. INTRODUCTION

Surveys of agricultural households over the last decade reveal tremendous changes in Rwandan agricultural outputs. The traditional Rwandan farmer has apparently responded to changing socio-political, agro-climactic, land resource, and economic circumstances by making radical shifts among crops. For some crops, the change in output may primarily be the result of secular shifts in productivity driven by lack of resistance to disease. In other cases, land availability, prevailing prices, lack of labor, lack of land, or food security may be the primary drivers behind substantial crop shifts by smallholders. The purpose of this discussion paper is to first document and highlight some of the major shifts in output over the past ten years, and then provide some working hypotheses about the reasons behind the changes. The paper also documents troubling trends in overall productivity in the traditional agriculture sector, underscoring the need for more off-farm employment and for improved agricultural input and output systems.

Our basic information draws from data collected by the Ministry of Agriculture's statistical unit[2] between 1986 and 2001, and builds on a 1992 publication looking at overall trends in Rwandan agriculture (MINAGRI, 1992). We focus our attention on two years. The 1990 data set reflects the situation in the last pre-war year during which data could be collected without political disruptions; the 1992 document shows only slight variations in crop output between 1984 and 1990. So 1990 is a good year to represent the pre-war status of agriculture. The 2001 data set is the most current available. In both years, the basic method of data collection is the farm-level household survey; commercial farms are therefore excluded from our sample. The information here reflects the situation among small farms, otherwise known as smallholders because they hold rights to farm small plots of land. The households are selected based on a statistically valid clustered random sample. Enumerators visit each household periodically for an entire crop year[3] to collect information about quantities harvested. The harvest information is complemented with measurements of the size of the household's fields and basic data about the characteristics (gender, age, etc.) of household members. Readers requiring a more complete description of the survey method are referred to Mpyisi et al., 2001.

The rest of this document is laid out as follows. Section two presents an overall comparison of 1990 and 2001 for all crops and animals covered by both surveys. Section three provides selected information at the provincial level, focusing attention where there has been substantial national change. Section four suggests potential explanations for the large shifts in Rwanda's agricultural sector, while section five shows the effects of the cropping changes on the household production of three macronutrients: kilocalories, proteins, and lipids. Section six sets forth conclusions and policy implications.

[2] The exact name of the unit changed over time from Service des Enquetes et Statistiques Agricoles, to Division des Statistiques Agricoles, and most recently Food Security Research Project, Division of Agricultural Statistics.
[3] The crop year runs from September through August.

II. CHANGES IN NATIONAL CROP OUTPUT AND LIVESTOCK INVENTORIES, 1990-2001

Figures 1 and 2 present changes in output of major smallholder crops between 1990 and 2001. In terms of percentage change, the greatest decreases were in coffee and bananas, while irish potatoes and cassava surged. When we consider change in tonnage, the dramatic **two million ton drop in banana output** dwarfs all other changes in the system, with a substantial reduction in sweet potatoes and large increases in irish potatoes and cassava.

Figure 1: Percent Crop Production Change, 1990-2001

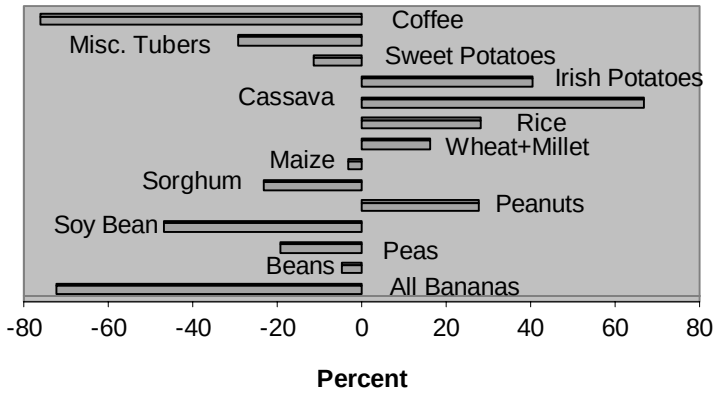
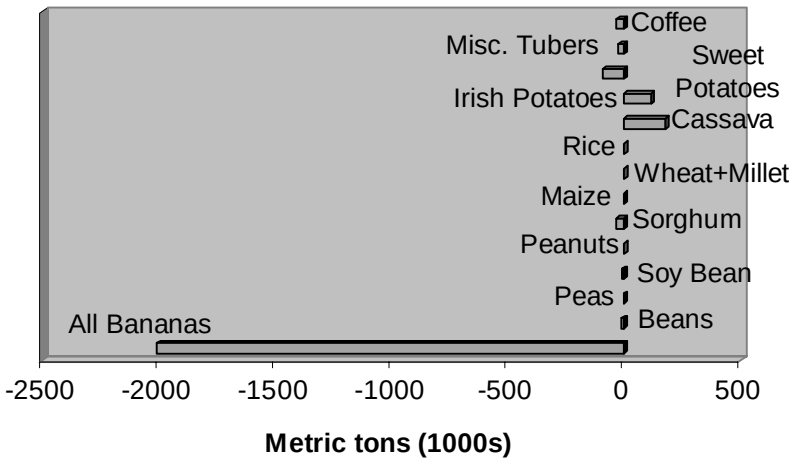


Figure 2: Crop Production Change in Tons, 1990-2001



Figures three and four show changes in smallholder livestock inventories between 1990 and 2001. While all categories except hogs declined, the most dramatic reductions are in poultry (mostly chickens), and goats.

Figure 3. Absolute Change in Livestock Inventory 1990-2001

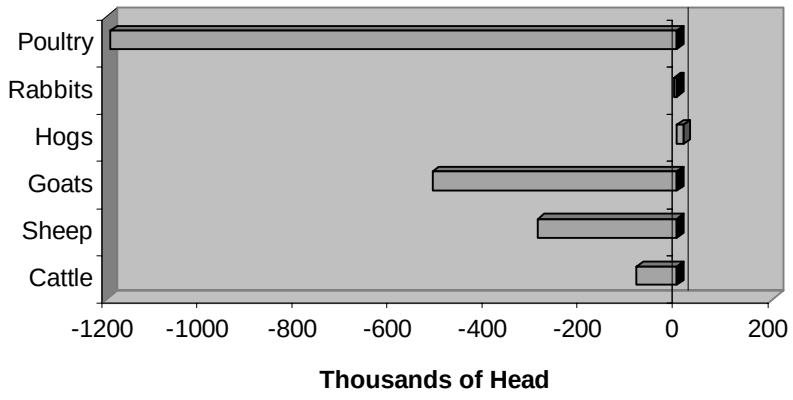
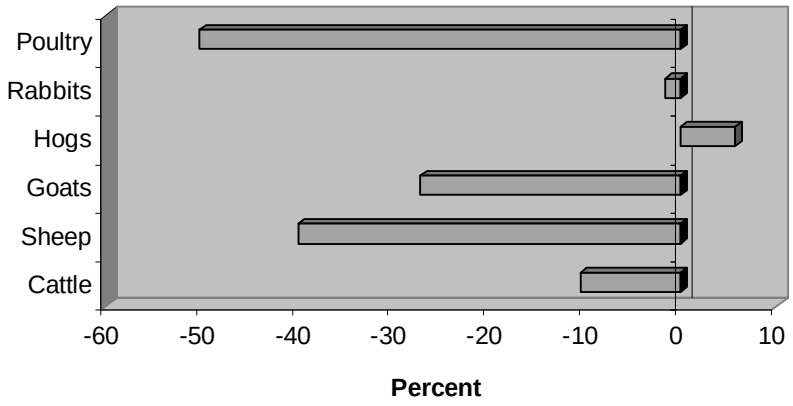


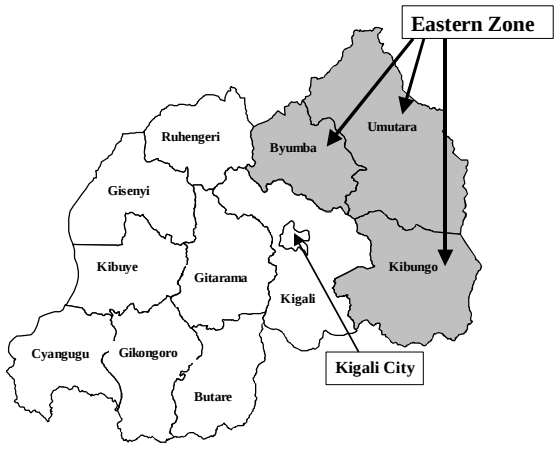
Figure 4. Percent Change in Livestock Inventory 1990-2001



III SELECTED COMPARISONS AT THE PROVINCIAL LEVEL

Section two documents major changes in five of Rwanda's most important crops: bananas, cassava, irish potatoes, coffee and sweet potatoes. It is unusual to see such dramatic shifts in a relatively short period of eleven years. This section explores patterns of the changes at the sub-national level. Because the borders of Byumba and Kibungo were redrawn in 1996 to create Umutara, direct comparisons of 1990 and 2001 production in these three provinces is only possible by aggregating them into a single "eastern zone" (Figure 5)[4].

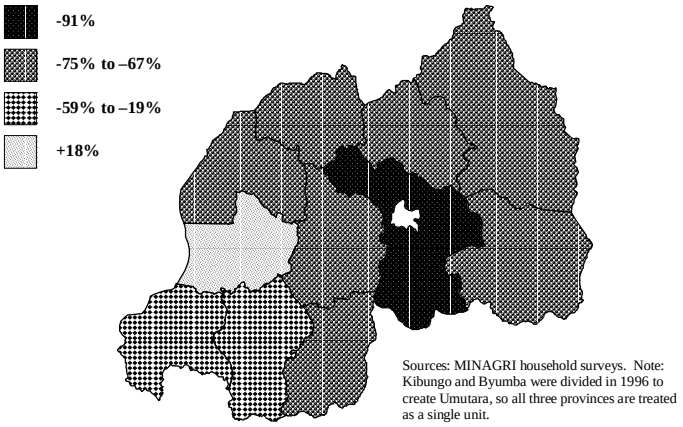
Figure 5. Rwandan Provinces and the Eastern Zone



We provide here five maps showing the distribution of the changes. The tonnages and exact percentages are available in Appendix 1.

Bananas. The map shows combined changes in brewing, cooking, and dessert bananas. Kibuye was the only part of the country with increased banana production. The reduction was most dramatic in the Kigali Rurale province, where output fell 91%. The areas surrounding Kigali Rurale also experienced substantial declines.

Figure 6. Change in Banana Production (All Varieties) by Province 1990 – 2001

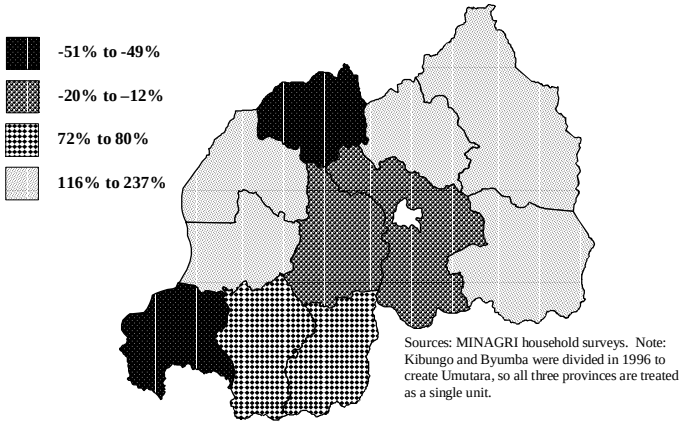


Sources: MINAGRI household surveys. Note: Kibungo and Byumba were divided in 1996 to create Umutara, so all three provinces are treated as a single unit.

[4] The eastern zone groups Byumba, Kibungo and Umutara as one region.

Irish Potatoes. Several regions experienced gains of over 100% in irish potatoes, and Butare and Gikongoro provinces also posted impressive gains. The traditional epicenter of Rwandan irish potato production, Ruhengeri, lost about fifty percent of its production.

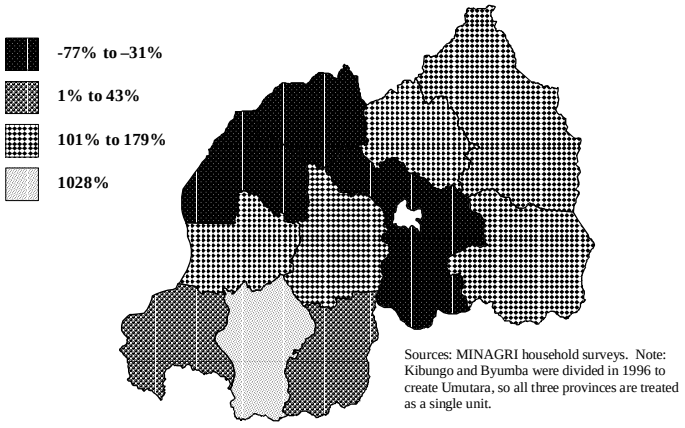
Figure 7. Change in Irish Potatoes Production by Province 1990 – 2001



Sources: MINAGRI household surveys. Note: Kibungo and Byumba were divided in 1996 to create Umutara, so all three provinces are treated as a single unit.

Cassava. One province (Gikongoro) showed a **ten-fold gain** in its cassava production, while the eastern zone, Gitarama, and Kibuye more than doubled their output.

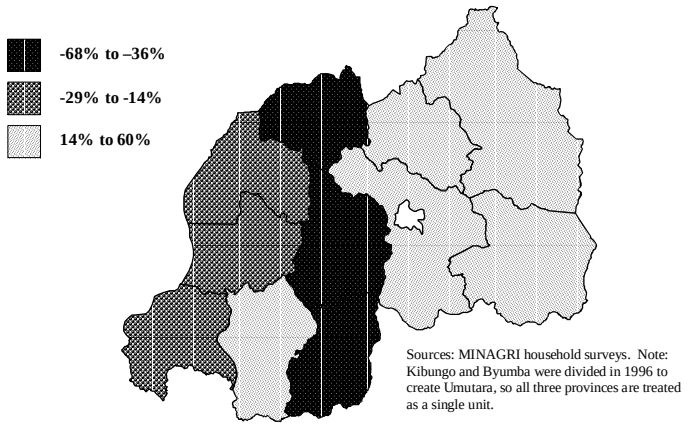
Figure 8. Change in Cassava Production (All Varieties) by Province 1990 – 2001



Sources: MINAGRI household surveys. Note: Kibungo and Byumba were divided in 1996 to create Umutara, so all three provinces are treated as a single unit.

Sweet Potatoes. The regions with the largest production losses cut a swath through the middle of Rwanda, including Ruhengeri, Gitarama, and Butare.

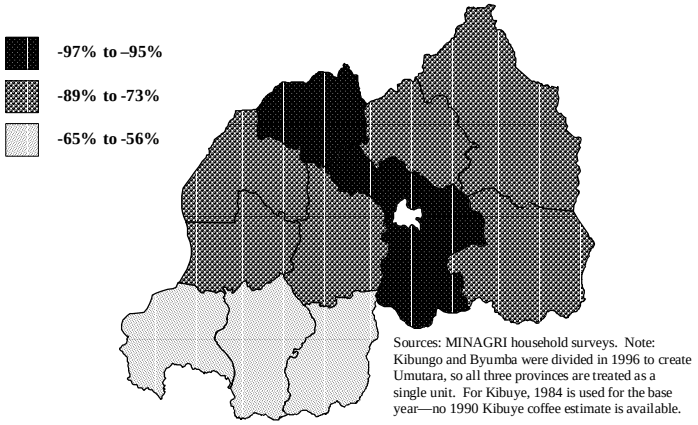
Figure 9. Change in Sweet Potato Production by Province 1990 – 2001



Sources: MINAGRI household surveys. Note: Kibungo and Byumba were divided in 1996 to create Umutara, so all three provinces are treated as a single unit.

Coffee. Both Ruhengeri and Kigali Rurale lost **almost all** their coffee production. Coffee harvests were substantially reduced in the other regions as well.

Figure 10. Change in Coffee Production by Province 1990 – 2001



Sources: MINAGRI household surveys. Note: Kibungo and Byumba were divided in 1996 to create Umutara, so all three provinces are treated as a single unit. For Kibuye, 1984 is used for the base year—no 1990 Kibuye coffee estimate is available.

Figures 11-13 show changes in inventories for cattle, poultry, and goats. Cyangugu managed to increase its inventory in all three types of livestock, while the eastern zone (Byumba, Kibungo, and Umutara) increased its cattle herd. Otherwise, all provinces have fewer cattle, poultry and goats.

Figure 11. Change in Cattle Inventories by Province 1990 – 2001

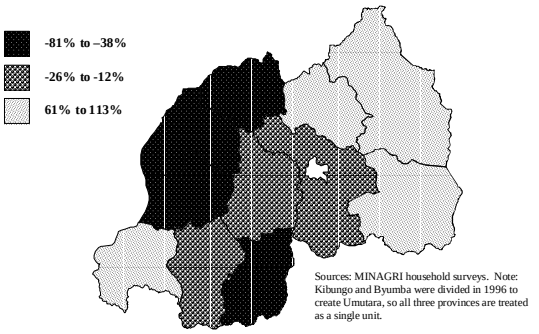


Figure 12. Change in Poultry Inventories by Province 1990 – 2001

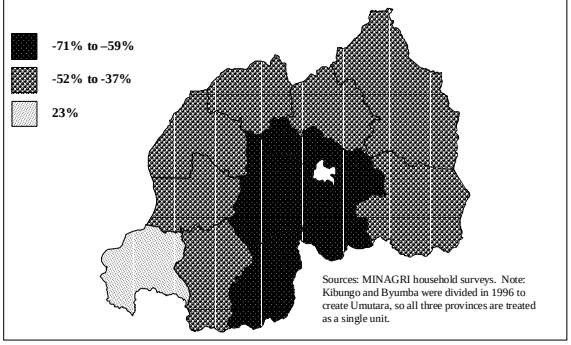
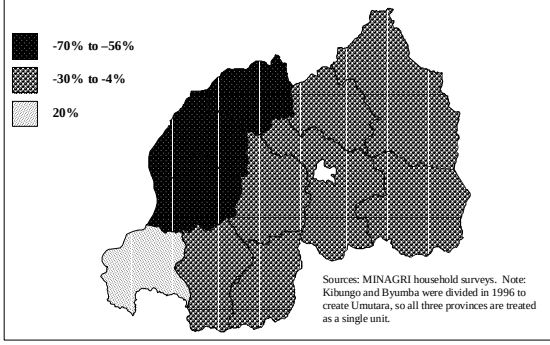


Figure 13. Change in Goat Inventories by Province 1990 – 2001



IV DRIVERS OF CHANGE IN RWANDAN AGRICULTURE

We now turn to exploration of potential reasons why agriculture in Rwanda changed so dramatically over the eleven-year interval. Change can come from differences in yields, area planted per farm, or number of households planting the crop. The production data themselves provide information about the number of households producing each crop. Table 1 presents the change in the percentage of households engaged in cropping each of the major crops. For example, in 1990 42% of farm households harvested coffee, but by 2001 only 18% of farm households produced the crop. So table 1 reports a change of negative 24 (18% minus 42%) for coffee. A main finding from table 1 is that fewer or more farmers growing a crop can provide an explanation for changes in overall output for some crops but not others. Coffee, sweet potatoes, and bananas all experienced national declines in output as well as declines in the proportion of households harvesting the crop. The proportion of households producing cassava declined while total output rose by sixty-seven percent. There was little change in the

proportion of households producing irish potatoes, while total national output rose by forty-one percent. The Province of Ruhengeri experienced declines in many major agricultural activities. Ruhengeri may be a special case of difficulties in the agricultural sector due to the armed conflict still active in the area.

Our discussion here is enhanced by interactions with a wide array of people who work in agriculture on a regular basis, and including MINAGRI personnel as well as National University of Rwanda agricultural faculty and staff of non-governmental organizations active in agriculture. We were pleased to learn that our data confirmed impressions the agricultural professionals had formed about overall crop production trends on a more casual basis through their field work. The possible reasons they listed for the changes in production vary substantially from crop to crop, so we treat crop each in turn.

Table 1
Change in Proportion of Households Producing a Crop, 1990-2001

Coffee	-24%
Sweet Potatoes	-10%
Irish Potatoes	1%
Cassava	-13%
Bananas (all types)	-19%
Misc. Tubers	-27%
Rice	-1%
Wheat/Millet	-1%
Maize	4%
Sorghum	-9%
Peanuts	2%
Soy	3%
Peas	-14%
Beans	0%

Bananas. Possible reasons for the huge drop in banana production include the following. First, widespread attacks of diseases are lowering banana output. This problem is exacerbated by lack of funds to multiply and distribute some of the new disease resistant varieties. Another reason is the droughts in 1997, 1998, and 2000 that affected banana production. Some also hypothesize that maintenance of banana fields has not been good due to political insecurity. There was also cutting of banana plants on the roadside in the North Eastern region for security reasons during the insurgency period. There have also been reports of increased theft from banana fields. This would not be the first time the Rwandan farmer has changed practices to cope with theft—many people still remember the disappearance of the traditional grain storage facilities that used to dot the countryside because of theft. Finally, some people mentioned the possibility of reduced soil fertility in banana fields, which were traditionally fertilized by manure. There has been a general drop in livestock in Rwanda for this purpose. Redirection of government resources towards other crops over the past few years may have contributed to the slide in banana production. Our data on the mix of crop outputs at the household level show substantially lower proportion households producing bananas in combination[5] with the following crops: sorghum, manioc, sweet potatoes, miscellaneous tubers, and coffee (see Appendix 3). Clearly, farms producing bananas in 2001 are less diversified in their crop mix than their 1990 counterparts.

Irish Potatoes. Our discussions about irish potatoes focused on the large national increase in production. Several people spoke of non-governmental organizations and government projects following the precedent established by an International Potato Center project in the 1980s that provided technical assistance, chemical inputs, and improved seed potatoes to farmers in the Ruhengeri area (Munyeman and von Oppen). These new projects seem to have extended the range of production to additional areas. Our contacts mentioned that potato inputs are now much more widely available than they had been before the war. Others noted new potato fields in the

[5] Based on crop outputs. The combinations may be intercropping or simply separate fields.

former Gishwati forest region, and increased interest by larger farmers in potato production due to the high returns in the mid-late 1990s.

Cassava. Our sources noted several potential reasons for the substantial increase in cassava production. First, the release of new cassava varieties may have increased yields. Many cassava cuttings were also distributed during the drought of 1999-2000. Another reason is increased surface area planted in cassava for the following risk avoidance reasons: drought-resistance, flood resistance, and ease of storage. Some noted increased national preference for consuming cassava-based dishes. Finally, some of our contacts mentioned a substitution out of sweet potatoes in favor of cassava. In support of this last point, our data (in Appendix 3) shows that output of cassava in combination with other tubers does seem to be in decline.

Sweet Potatoes. Possible reasons for the drop in sweet potato production include the poor rains in 1997, 1998, and 2000. The lack of rain reduced yields and also created a shortage of planting material. Our sources also reported widespread sweet potato diseases. There were also reports of caterpillar infestations of sweet potato fields. The proportion of households producing sweet potatoes dropped by ten percent. There seems to have been a move away from other traditional tubers, as the proportion of households growing miscellaneous tubers also dropped substantially—by twenty-seven percent.

Coffee. The production estimates in the MINAGRI data track the statistics collected by OCIR/Café on exports even though the two methods of data collection are radically different (Loveridge, Mpyisi, and Weber). International prices have dropped consistently over the past decade, and Rwandan coffee quality has not kept pace with international standards. Rwanda has liberalized its policies in terms of farmer's options for coffee fields—previously intercropping was not allowed, farmers were not allowed to remove coffee once it was planted, and they were required to apply mulch to any coffee fields. Finally, farmer training and chemical input subsidies and new varieties available before the war are no longer provided. Accordingly, farmers have abandoned fields, existing coffee trees are quite old, and yields are probably low.

V CHANGES IN FARM LEVEL PRODUCTION OF MACRONUTRIENTS

The shifts in production indicated above will have consequences on the availability of energy (kilocalories), fats (lipids) and proteins for rural Rwandan households. Earlier research (Loveridge 1992) has shown that rural households obtain a majority of their macronutrients from own production, rather than purchased foods, and the crops included here provided an average of 50% of lipids, 95% of the proteins, and 96% of the calories consumed by rural households. We do not include here horticultural crops or livestock items. We converted total production by the household to per adult equivalent amount of the three basic macronutrients, summing across 14 major food crops.

Figure 14: Change in Percentage of Kilocalorie Requirement met through Own Production by Province, based on 2,100 kilocalories per day per adult, 1990-2001 based on 2100 kilocalories per day per adult

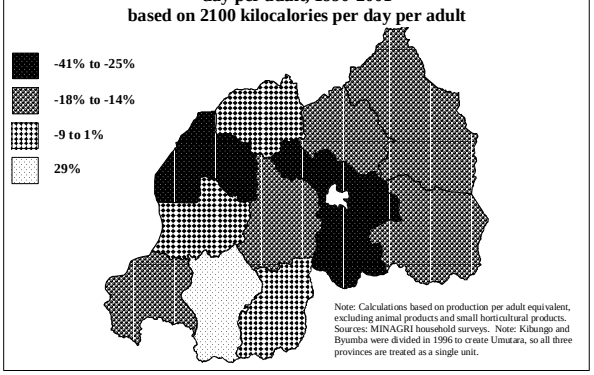


Figure 15: Change in Percentage of Protein Requirement met through Own Production by Province, 1990-2001 based on 59 grams per person per day

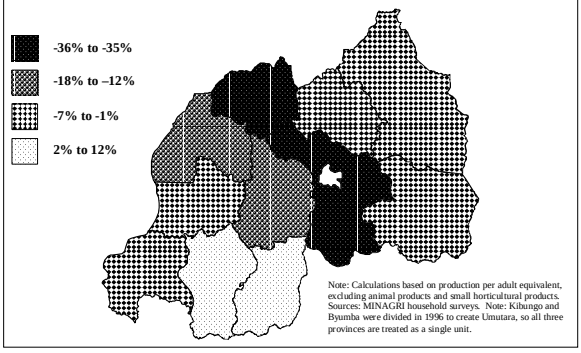


Figure 16: Change in Percentage of Lipid Requirement met through Own Production by Province, 1990-2001 based on 40 grams per person per day

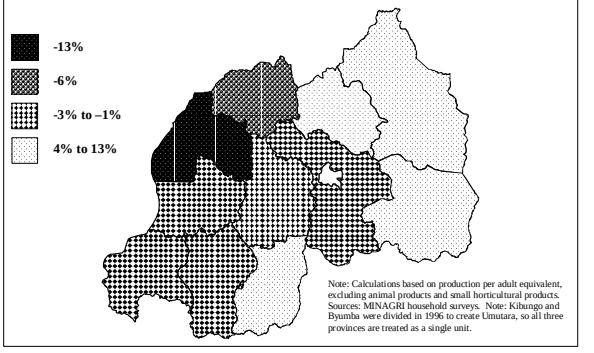


Figure 17: Percentage of Kilocalorie Requirement met through Own Production in 2001 by Province

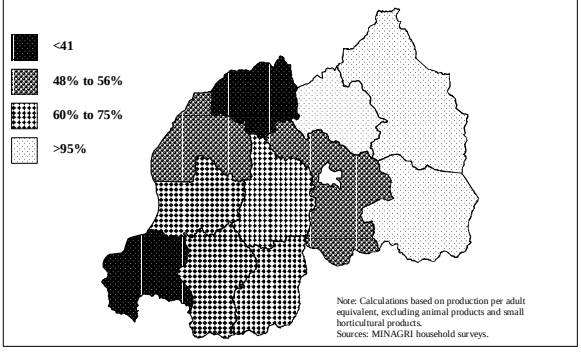


Figure 18: 2001 Percentage of Proteins Requirement met through Home Production by Province

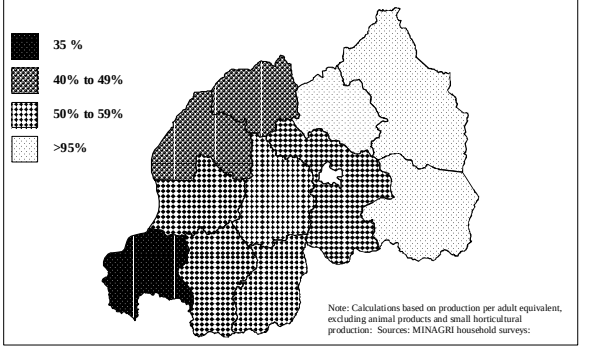
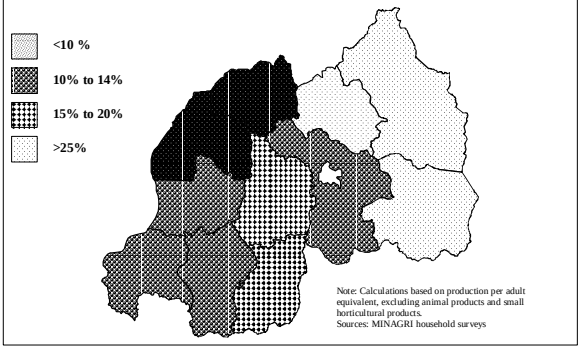


Figure 19: 2001 Percentage of Lipid Requirement met through Home Production by Province



For kilocalories, based on a daily need of 2,100 kilocalories per adult equivalent, on average 83% of minimum needs could be met from home production in 1990, yet only 63% of needs could be met in 2001, with much of the decline due to reduced production of bananas. Protein production also declined, going from 71% of needs in 1990 to 60% in 2001,with lowered production of sweet potatoes and various other crops. Lipid production remained about 17% of requirements between 1990 and 2001. Since animal products may have provided lipids and proteins in the past and herds have declined, it is likely that overall production of both have declined more than indicated here, particularly for lipids.

As with the production shifts, the provincial macronutrient production estimates show varying results. While the national average for lipid production remained stable, in the Eastern Zone, lipid production increased from 25% to 38% of needs, Butare increased from 15% to 19% of needs, while in each of the other provinces there was a decline. Peanut production increases

Table 2: Ability to meet daily adult requirement for kilocalories, proteins and lipids, from per adult equivalent production of basic food crops

	Kilocalories			Proteins			Lipids		
	1990	**2001**	**Change**	**1990**	**2001**	**Change**	**1990**	**2001**	**Change**
Butare	69%	60%	-9%	57%	59%	2%	15%	19%	4%
Cyangugu	54%	39%	-14%	42%	35%	-7%	12%	10%	-2%
Gikongoro	46%	75%	29%	38%	50%	12%	12%	10%	-2%
Gisenyi	73%	48%	-25%	60%	43%	-18%	20%	7%	-13%
Gitarama	79%	65%	-14%	63%	51%	-12%	16%	15%	-1%
Kibuye	59%	61%	1%	52%	50%	-2%	15%	13%	-3%
Kigali Rural	94%	52%	-41%	88%	52%	-36%	16%	13%	-3%
Ruhengeri	89%	40%	-49%	81%	46%	-35%	15%	8%	-6%
Eastern Zone	120%	101%	-18%	104%	103%	-1%	25%	38%	13%
Rwanda	83%	65%	-18%	71%	60%	-11%	17%	17%	0%

Note: Animal and horicultural product consumption and consumption from purchased or donated goods not included.
Assumes that what is produced in the province is consumed by rural households in the province.
Source: MINAGRI household surveys, 1990 and 2001.

were important in Butare and the Eastern Zone. The highest decline was in Gisenyi, where it dipped from 20% of needs in 1990 to 7% in 2001. This shift is related to the decline in the production of maize.

For proteins, bean production is very important in Rwanda. The strong decline in Kigali Rural can be attributed to declines in beans, as was the case in Ruhengeri as well. There was an increase in sorghum production in Kigali rural which helped offset the losses. In Gikongoro, where proteins increased significantly, the improvement was largely due to beans. Animal sources of protein may be available in some of these provinces to complement the sources from cropping, particularly in Gikongoro where poultry production is on the rise.

The general decline in macronutrient production throughout the country signifies potential threats to food security in rural areas, unless there are improvements in off-farm income to enable the purchase of consumption goods.

VI CONCLUSIONS AND POLICY IMPLICATIONS

Rwanda's agriculture, while relatively stagnant in terms of technology and limited in terms of resources, is highly dynamic in one sense. It is capable of adapting quite quickly in response to new opportunities and constraints. Smallholders appear to seize new varieties and input availability with alacrity, as in the cases of irish potatoes and cassava. They also seem capable of quickly moving away from crops that are no longer profitable (coffee) or crops with declining yields (bananas and sweet potatoes). Farmers continue to hedge their risk through diversification of their crop portfolio, producing an average of 6.42 crops per household in 2001. Despite these positive aspects of Rwanda's agriculture, our trend data overall reveal some troubling trends deserving attention from policy makers.

1. **Soil Fertility.** Among crops common in Rwanda, coffee and bananas provide the greatest protection against erosion (Appendix 4). Decreased area in crops providing good soil protection such as bananas and mulched coffee could have rapid deleterious effects on Rwanda's soil fertility, particularly if these crops are replaced with cassava or cereals. Soil fertility was a major policy concern even before the crop shifts we document here (Clay). The problem is compounded by lack of fertilizer and the rapid decline in fallow fields documented by Mpyisi et al. Loss of manure due to reduced livestock inventories is another factor leading to a conclusion that soil fertility is increasingly at risk. More research is needed to help identify ways to sustain or build soil fertility under the prevailing conditions. Only 6.9% of households report using purchased inputs (MINECOFIN, 2002). When research is available, Extension efforts should also include more attention to soil fertility.

2. **Other Yield Enhancement Measures.** More research is also needed on varietal improvements to increase resistance to disease and yields for selected crops, particularly bananas. The feasibility of chemical or other treatments to reduce disease should also be explored.

3. **Potential of Reduced Access to the Cash Economy.** In 1990, bananas (including brewed bananas) and coffee were by far the two largest sources of cash income for Rwandan agricultural households (Kangasniemi). The reduced animal inventories we document above may exacerbate loss of cash resources. The substantial declines in these cash-generating activities may translate into reduced access to market goods. Nationally, only 60% of households sell any of their agricultural output (MINECOFIN, 2002). The limited access to cash may impact their ability to acquire improved inputs when opportunities arise.

4. **Effect of Crop Mix on Food Security.** Production of beans, peas and soy beans all declined in overall terms since 1990. In adult equivalent terms, production is clearly reduced. Movement away from these high protein crops and animal agriculture may

imply a less healthy diet unless the gap is made up through imports of protein-rich foods. Chronic food insecurity may increase. Rural Rwandans have been able to purchase substantial quantities of imported beans in the past (Loveridge), but with reduced access to cash, this strategy may not be feasible in the future.

5. **Marketing Infrastructure.** Improved systems to process and deliver Rwandan agricultural outputs to the national and international market are needed. Rwanda's climate is highly advantageous for export to the northern hemisphere, but these markets cannot be reached without better secondary roads, market information systems, and agricultural processing facilities. Improved marketing infrastructure will also help farm families combat nutritional deficiencies through lower cost food imports, and lower the cost of agricultural inputs.

6. **Extension Services.** During the 80s and early 90s several regional government projects (DRB, PDAG, etc.) supported extension services and the government had many more extension agents called "monagris". The "monagri" system was abolished and the model of regional government projects is resulting in reduced farmer access to extension services. Yet farmers indicate that lack of knowledge is the principal reason for not using fertilizers to enhance productivity (Kelly et al.). Farmer organizations and NGOs are increasingly responsible for providing extension services but with short project cycles, little institutional capacity may be built for the long term (Bingen and Munyankusi). Project-based extension initiatives should build training of permanent extension counterparts into their activities.

In summary, Rwanda's farmers are faced with a variety of forces, some favorable and others unfavorable. Rural households are responding to pressures created by reduced availability of land per capita, reduced prices and yields of selected crops, and availability of improved inputs and varieties in other crops. If better systems to support agriculture are put into place, the sector will respond with greater productivity.

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Appendix 1. Production in Tons by Region 1990 and 2001 with Percentage Changes.

	Butare	Cyang.	Gikong.	Gisenyi	Gitarama	Kibuye	Kigali Rural	Ruheng.	Umutara	East Zone	Rwanda
Bananas											
1990	240642	147864	55433	150523	414637	50431	568824	180025	0	968388	2776767
2001	68278	60673	44755	49687	103035	59699	48661	46179	38644	289832	809443
Change	-72%	-59%	-19%	-67%	-75%	18%	-91%	-74%		-70%	-71%
Cassava											
1990	43689	23412	5298	5963	66289	8083	65266	5951	0	41240	265191
2001	44248	33583	59759	4106	133372	21862	29219	1374	11845	114894	454262
Change	1%	43%	1028%	-31%	101%	170%	-55%	-77%		179%	71%
Irish Potatoes											
1990	4801	3045	7672	68004	4922	11723	5783	163756	0	13967	283673
2001	8664	1555	13184	208971	4312	29523	4602	80832	9726	47117	408486
Change	80%	-49%	72%	207%	-12%	152%	-20%	-51%		237%	44%
Sweet Potatoes											
1990	122332	35562	78787	66664	124980	57498	81307	114664	0	135945	817739
2001	77838	26618	111157	47028	65852	49238	92595	37085	28560	217916	753887
Change	-36%	-25%	41%	-29%	-47%	-14%	14%	-68%		60%	-8%
Coffee											
1990	3151	5724	1456	8525	7435	2508[6]	7026	453	0	7074	40844
2001	1110	2515	635	1824	1108	281	380	15	139	1931	9938
Change	-65%	-56%	-56%	-79%	-85%	-89%	-95%	-97%		-73%	-76%

The borders of Byumba and Kibungo were redrawn in 1996 to create Umutara. So all three provinces are combined into the "Eastern Zone" for purposes of this paper.

[6] Kibuye coffee production was not estimated in 1990. We substituted data from 1984 to estimate percentage change for coffee in Kibuye.

Appendix 2. Livestock Inventory by Region, 1990 and 2001, with Percentage Changes

	Butare	Cyangugu	Gikongoro	Gisenyi	Gitarama	Kibuye	Kigali Rural	Ruhengeri	East Zone	Rwanda
Cattle										
1990	127977	20403	66224	60054	159697	92327	111079	63695	111959	813415
2001	72434	32747	58273	11216	140212	56965	82061	35644	238645	728197
Change	-43%	61%	-12%	-81%	-12%	-38%	-26%	-44%	113%	-12%
Sheep										
1990	33953	20004	65656	99877	33524	82002	65468	185683	146833	733000
2001	10957	7173	61798	34574	15758	101087	23093	108254	77684	440378
Change	-68%	-64%	-6%	-65%	-53%	23%	-65%	-42%	-47%	-66%
Goats										
1990	162620	102445	111059	170066	152257	223805	299722	155223	514416	1891613
2001	139725	122787	106184	51848	111070	111966	208773	68608	456607	1377568
Change	-14%	20%	-4%	-70%	-27%	-50%	-30%	-56%	-11%	-37%
Pigs										
1990	55191	23287	62187	4582	26830	2326	3018	17716	49843	244980
2001	50141	19386	79832	8916	27440	5838	21564	20171	25614	258902
Change	-9%	-17%	28%	95%	2%	151%	615%	14%	-49%	5%
Rabbits										
1990	48005	11988	21840	50527	84696	11329	73868	37633	108952	448838
2001	35641	3850	34752	60899	65884	9864	19670	125905	85281	441746
Change	-26%	-68%	59%	21%	-22%	-13%	-73%	235%	-22%	-2%
Poultry										
1990	355059	79723	73889	119826	367842	89478	438638	207000	642287	2373742
2001	147296	98225	35162	73301	105646	51230	136501	129801	404886	1182048
Change	-59%	23%	-52%	-39%	-71%	-43%	-69%	-37%	-37%	-101%

Note: the east zone includes Umutara, Byumba, and Kibungo. These provinces are aggregated because Umutara was created in 1996 by redrawing the lines for Byumba and Kibungo.

Appendix 3. Change in Percentage of Households with Various Combinations of Outputs

This table was produced by first calculating the percentage of households growing each combination of major crops in 1990 and in 2001. Then the 1990 percentage was subtracted from the 2001 percentage to yield the change in pairwise crop output combinations. Note that the table provides no information about the fields on which the pairs of crops are grown. They may have been grown in intercropped fields or in separate monocropped fields. As examples of how to read the table, we interpret two cells. The beans-beans cell is 0%, meaning the percentage of households producing beans was the same in 1990 and 2001. The beans-peas cell is –15%, meaning that 15% fewer households produced both beans and peas in 2001 than was the case in 1990. Since the peas-peas cell is –14%, we can assume that most of the change in the beans-peas output combination is the result of fewer households growing peas.

	Beans	Peas	Ground Nuts	Soy	Sorgh.	Wheat & Millet	Rice	Cas-sava	Potato	Sweet Potato	Other Tubers	Banana	Coffee	Maize
Beans	0%													
Peas	-15%	-14%												
Ground Nuts	3%	0%	2%											
Soy	4%	-6%	6%	3%										
Sorghum	-8%	-12%	3%	1%	-9%									
Wheat/Millet	-1%	-3%	1%	-2%	-3%	-1%								
Rice	-1%	-1%	0%	0%	0%	0%	-1%							
Cassava	-12%	-13%	0%	1%	-11%	-2%	0%	-13%						
Potatoes	0%	-9%	3%	-5%	-3%	1%	0%	-7%	1%					
Sweet Potatoes	-8%	-16%	2%	1%	-12%	-5%	-1%	-16%	-5%	-10%				
Other Tubers	-26%	-20%	-2%	-8%	-22%	-5%	-1%	-24%	-15%	-29%	-27%			
Bananas	-17%	-17%	0%	-3%	-21%	-4%	-1%	-22%	-7%	-22%	-30%	-19%		
Coffee	-23%	-14%	-5%	-10%	-19%	-2%	0%	-22%	-13%	-25%	-22%	-25%	-24%	
Maize	-5%	-14%	3%	4%	-7%	-2%	0%	-10%	-2%	-11%	-24%	-17%	-20%	4%

Appendix 4. Erosivity of Crop Cover

Higher c-values indicate higher propensity for land to suffer from erosion when planted in the crop.

Erosivity of Crop Cover	
Crop	**C-value**
Coffee	0.02
Banana	0.04
Banana/beans	0.10
Manioc/banana	0.10
Fallow	0.10
Pasture	0.10
Woodlot	0.10
Beans/banana	0.12
Banana/sorghum	0.14
Peas	0.15
Sorghum/banana	0.18
Beans	0.19
Beans/potato	0.20
Beans/sweet potato	0.20
Peanut/beans	0.21
Manioc/beans	0.22
Potato	0.22
Sweet Potato	0.23
Eleusine	0.25
Manioc	0.26
Maize/beans	0.30
Sorghum/manioc	0.31
Cocoyam	0.33
Maize	0.35
Sorghum	0.40
Tobacco	0.45

Source: Lewis (1988).