FARM-LEVEL INCENTIVES FOR FERTILIZER USE IN RWANDA'S KIGALI RURAL PROVINCE: A FINANCIAL ANALYSIS

By

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LIST OF ABBREVIATIONS

AE	Adult equivalent
DAP	Diammonium phosphate
FAO	Food and Agriculture Organization of the United Nations
Frw	Rwanda francs (550Frws = $1)
FSRP	Food Security Research Project
GOR	Government of Rwanda
ISAR	National Agricultural Research Institute of Rwanda
LISA	Low-Input Sustainable Agriculture
MINAGRI	(Rwanda's) Ministry of Agriculture, Forestry and Livestock
MINECOFIN	(Rwanda's) Ministry of Finance and Economic Planning
PASAR	Projet d'appui à la sécurité alimentaire au Rwanda (Food security support project)

CHAPTER 1

INTRODUCTION

1.1 Problem setting

Rwanda has one of the highest population densities in Africa and faces a real problem of land scarcity. Muller (1997) after using data collected during the agricultural year 1982-1983, notes that the average land area farmed by each household was at that time already very small (1.24 ha), but it enabled the average household to obtain a surplus of about 10% of the average consumption. The declining availability of farmland is a consequence of population pressure, the local inheritance system and the lack of sustainable livelihood alternatives for less educated people. With an inheritance system in which each son inherits an equal amount of land from his father, each generation has a shrinking of farm sizes in areas where supplemental land to clear or buy is difficult to attain (Olson 1994).

The Household Living Condition Survey (EICV) conducted in 2001 reveals that as many as 47.7% of households in Rwanda own land area less than or equal to 0.5 hectare, disregarding the quality of the farmland (MINECOFIN[1], 2002). Farmers have responded sequentially to increased pressure on land use over time in ways ranging from different types and level of intensification to demographic responses (migration and reducing the number of births) via non- and off-farm income activities. Harrison (cited in Kangasniemi 1998) notes that in Rwanda, one of the few African countries where food production increased faster than population in 1960-1980, agriculture apparently failed to

[1] Ministry of Finance and Economic Planning

keep pace with population growth after the mid-1980s, when the land frontier became virtually exhausted.

In spite of the problem of land scarcity, agriculture and livestock are still considered as the primary engine of economic growth in Rwanda. It is assumed indeed that increased agricultural incomes must be achieved by transforming Rwanda's traditional agriculture through the use of new and improved inputs. The Government of Rwanda in its "poverty reduction strategy paper" (MINECOFIN 2001) refers to recent studies (Kelly and Murekezi 2000, Kelly et al. 2001, Mellor 2001) when expressing its motivation on promoting the use of chemical fertilizer. These studies show that as so little fertilizer is used (five percent of farmers on three percent of total cultivated area) it has very high marginal returns and, if correctly used, would be highly profitable for farmers. The increase and more efficient use of fertilizer is expected to contribute 4% of the 5.3% growth of the agriculture sector. The GOR[2] intends to rely on a selected range of commodities to achieve economic growth. Key among these commodities are climbing beans, maize, sorghum and soybeans which are selected because of their high nutritional value, their importance in the cropping pattern of the country and adaptability to the country's agro-climatic zones, and for their potential to respond to organic and chemical inputs.

Land scarcity in Rwanda and its potential improvements have been the subject of many studies and many questions have been answered in the past, but the answers must be constantly reexamined in light of the changes that occur with time. The purpose of this study is to inform agricultural policies in Rwanda by evaluating the profitability of some food crops in the context of the current government policy of promoting the use by

[2] GOR "Government of Rwanda"

farmers of improved inputs**.** More specifically, we ask what are the magnitudes of costs associated with the use of fertilizer on climbing beans, maize, sorghum and soybeans grown in the province of Kigali rural and whether revenues are big enough to generate attractive margins. We also analyze some recent survey data seeking to put crop production in a wider perspective of the household's limitations and/or opportunities when dealing with the issue of improving crop yields on farmer's land.

Previous studies on fertilizer profitability in Rwanda, in particular the Kelly and Murekezi (2000) study, used the value/cost ratio approach to estimate the probable financial returns to the use of fertilizer for selected crop/zone combinations. The value/cost ratio calculated in this study is the incremental gross revenue due to the use of mineral fertilizer divided by the incremental cost of fertilizers. The data needed to estimate this criterion are then the gross revenues and the fertilizer costs from without and with mineral fertilizer alternatives. Treatments are classified as profitable at the farm level when v/c ratio equals or exceeds 2. The above mentioned authors' opinion is that cases where the v/c ratio is 3 or better are cases where fertilizer promotion is most likely to succeed in short-run. The analysis in their study was done with prices prevailing from 1995 to 1999 whereas this paper uses 2000- 2001 prices. The decline of output prices since then would explain some of the differences in the results

The v/c ratio approach like any other analytical tool has strengths and weaknesses. It is the more appropriate when the profitability study deals with a high number of crop/zone combinations since it is not very demanding in terms of quantity of data. The most important weakness of this approach is then the fact that it is very sensitive to the change of inputs and output prices since very few items are considered.

When comparing profits or profitability among different crops, the budget analysis approach is stronger than v/c ratio since it takes into account all income and costs of a specific crop to provide a more thorough estimate of its profit.

The contribution of this paper is twofold. First, fertilizer profitability is analyzed with full budget analysis and conclusions are drawn about what technology choices farmers are likely to make given differences in returns to limited resources such as labor and cash. Second, the study focuses on the province of Kigali rural and draws conclusions about what the different profitability results imply about possible needed changes in extension recommendations for that province.

This paper has focused on Kigali rural province for two major reasons. First, according to the Government of Rwanda's Poverty Reduction Strategy Paper, regionally, the increased input use would be concentrated in three provinces, Gisenyi, Ruhengeri and Kigali rural. Second, Kigali rural province includes some of the poorest areas in the country and has the lowest level of fertilizer use compared to the two other provinces. Gisenyi and Ruhengeri provinces have the highest level of fertilizer use in Rwanda due mostly to potato production.

1.2 Organization of the paper.

This paper is organized as follows. Chapter one is devoted to introductory remarks, background, and the overall objectives of the paper.

Chapter 2 introduces the reader to general concepts related to agricultural intensification, and major findings of previous research on agricultural intensification in Rwanda, particularly on soil conservation and chemical fertilizer use.

Chapter 3 gives the big picture of the agricultural sector in Kigali rural province. First, it presents the general characteristics of the three major agro-ecological zones. The associated agricultural calendars are described. Second, it presents a brief analysis of farm resources, in particular household characteristics and available land by household and by adult equivalent, using recent data. The last section of the chapter derives crop production and land use patterns from recent quantitative survey data in the Kigali rural province.

Chapter 4 presents the crop budgets elaborated for Kigali rural province and analyzes the financial margins, the returns to family labor and the remuneration rates, for selected food crops, specifically climbing beans, maize, sorghum and soybeans in both the plateau central and plateau de l'Est agro-ecological zones, and sorghum in Bugesera zone. The crop budget analysis includes a calculation of revenues and costs whereas the financial margin analysis consists of the calculation of three margins: the gross margin, the total gross margin and the net margin.

Chapter 5 summarizes the major findings both on the characteristics of farm households, landholdings, and cropping systems in Kigali rural province, and from crop budget analysis, discusses policy implications and notes limitations of the study.

CHAPTER 2

BRIEF REVIEW OF AGRICULTURAL INTENSIFICATION LITERATURE AND ITS RELEVANCE TO RWANDA

2.1 General Concepts

2.1.1 Introduction

Two major views characterize the literature on the idea of diminishing returns, the neo-Malthusian and the Boserupian. Malthus along with other classical economists believed that when population grows, farmers increase production either by cultivating poor lands (extensive margins) or by adopting practices previously considered too laborious (intensive margin), resulting finally in a reduction in access to food. Although classical economists such as Malthus were well aware that as population densities grew, people would innovate and adopt more productive methods, they failed to appreciate how technical progress could help to increase the frequency of cropping by reducing the need for fallows (Boserup 1989). Boserup (1965, 1981), states that while population pressure first leads to diminishing returns, inducing people to adopt more labor-intensive practices, it also enables and encourages them to develop and adopt innovations that mitigate or even reverse the decline in labor productivity that would otherwise follow. She recognizes, however, that if people fail to invent or adopt other measures of fertility restoration when they shorten the period of fallow, they may mine their soils and be left with the choice between starvation and/or migration.

The invention or adoption of innovations that help to restore soil fertility is induced by a couple of factors. Boserup (1989) demonstrates how changes in population

density in a variety of environments had pushed agricultural societies from one farming system to another. Kates, Hyden and Turner II (1993) consider the relationship between population and agricultural intensification as being modified by two sets of variables: market access and environmental conditions. They hypothesize that the success of agricultural intensification in responding to demographic change depends crucially on the environmental and market conditions in which it is taking place. Harrison et al. (1987) found that improvements in agricultural productivity are dependent on simultaneous fulfillment of several conditions. They said that farmers must have a reasonable expectation of a remunerative market outlet, and have access to new and more productive technologies and physical inputs (land, labor, and capital goods) needed to produce under more efficient arrangements. In this section we discuss in brief how some of the above factors affect intensification, especially market incentives, environmental conditions, availability of intensification techniques and capacity to invest.

2.1.2 Market incentives

Farm-level incentives to invest are determined by returns (financial or physical) on investments that households make to generate an income from farm assets. Better returns to agriculture lead in general to more land conservation and soil fertility investments. Schultz (1964) and Hayami and Ruttan (1985) argued that small farmers respond to market incentives. Reasons behind farmers' responses are threefold. First, output markets can make intensification profitable and provide farmers with resources to invest in land. Second, access to markets and relative market prices influence crop choice. Third, input markets may promote or discourage specific forms of intensification.

In general all input use (except for land) contributes to intensification. However some of them may be unsustainable, bringing short-term gains at the expense of long-term production losses. Chemical fertilizer is often regarded as such an input. Cheap mineral fertilizer may encourage farmers to neglect soil conservation or the organic fertilizers that would provide both the nutrients and the humus. This neglect results in the loss of organic matter. On the other hand, *ceteris paribus,* mineral fertilizer increases crop biomass, which means better crop cover against erosion and more organic matter that can be used to improve soil quality. A German project (PAP) that sponsored research on "ecofarming" in Rwanda and which originally had been quite critical of "artificial fertilizer," found that the leguminous plants were difficult to establish on degraded lands without mineral fertilizer (Egger and Rottach, cited in Kangasniemi 1998).

Briefly said, paraphrasing Reardon et al. (1995), market conditions that reward farmers for investing in their lands, for using inputs and techniques that maintain or improve land fertility, and for choosing crops that provide high returns without mining the soil contribute to sustainable intensification.

2.1.3 Environmental conditions

Ruthenberg's classical work on farming systems (1980) reveals that while population growth leads to the evolution of farming systems, environment limits the options. When discussing LISA[3] and intensification technologies that combine elements of LISA with the use of fertilizer and equipment as a technological option for African agriculture development, Reardon (1998) demonstrates how the relative emphasis given

[3] LISA is a broad technological option for intensification that uses little inorganic fertilizer and equipment: Low-Input Sustainable Agriculture.

to each path differs by agroecological zone. He shows that in the more fragile agroclimates, LISA is more appropriate, while in the more favorable agroclimates, crop output growth and soil fertility needs are best served by supplementing the organic matter application and soil conservation techniques of LISA with capital-using intensification.

The warmer and more humid the climate, the greater is the degradation of tropical soils under permanent upland cultivation without mineral or organic fertilizer. In fact, high temperature promotes rapid decomposition and high rainfall contributes to leaching and erosion. The loss of organic matter increases the leaching of nutrients to the subsoil, while reducing infiltration. Soils located on steep slopes, impoverished in organic matter and water infiltration capacity, and not protected against erosive impact of raindrops, are more vulnerable to large soil losses.

On the other hand, the fertility loss is generally less severe on the cool, tropical highlands, in semi-arid climates, and on fertile volcanic soils. Continuous cultivation of annual crops can be sustainable in these environments if some anti-erosive techniques are implemented. Although cooler climates make tropical highlands more conducive to permanent cultivation than lowlands, suggesting better prospects for intensification, many of the highlands already have high population densities. Moreover, highlands often have steep slopes and poor, shallow soils, which make them vulnerable to erosion. Uwizeyimana cited in Kangasniemi (1998) describes how intensification is failing in Rwanda on the chain of mountains that form the divide between the basins of the Congo and the Nile, concluding that agricultural intensification there is reaching a dead end. In contrast to the generally impoverished Congo-Nile divide highlands, the volcanic part of

the divide is Rwanda's potato basket with high yields, reasonable incomes and moderate level of soil losses.

In sum, environmental conditions such as rainfall, soil type, steepness of slope, and temperature constitute strong determinants of agricultural intensification. Prospects are good for regions with fertile soils, abundant rainfall and modest rates of organic matter decomposition.

2.1.4 Availability of intensification techniques

All other factors held constant, prospects for sustainable agriculture are good for populations that have a variety of attractive intensification techniques to choose from. Lipton (1990) argues forcefully that the principal constraint of agricultural growth in much of Africa is the poor supply of improved agricultural technologies.

Technical innovations that save scarce factors of production are relatively profitable for agricultural producers. Farmers are induced by shifts in relative prices of these innovations. Ruttan and Hayami (1998) have found that farmers press the public research institutions to develop the new technologies and demand that agricultural supply firms supply modern technical inputs that substitute for the more scarce factors. In Ruhengeri, Rwanda, progress had been partly based on the development of improved potato varieties by ISAR[4], the provision of fungicides they needed, and the construction of a paved road from the region to the capital, the main market for potatoes.

[4] Rwanda Agricultural Research Institute

2.1.5 Capacity to invest

While the incentive to invest in land and to adopt the appropriate intensification techniques is in place, households may not have resources to invest (Clay et al., 1998). Resources include cash for purchase, human capital, and own-labor sources for home production of capital goods.

Kelly et al. (2001b) illustrate the concept of capacity to invest when trying to explain the big gap between potential fertilizer demand and fertilizer effective demand in Rwanda. They say that "if farmers do not know about the economic incentives associated with fertilizer, there is a human capital constraint that needs to be lifted by improving knowledge; if farmers do not purchase fertilizer because they do not have the financial capital, there is a need to build financial capital through savings and credit programs; if farmers do not purchase fertilizer because they do not have the physical capital to use it properly (anti-erosion investments, animals to provide complementary manure, farming tools and equipment, etc.), the constraint needs to be addressed for agro-economic potential to be translated into effective demand."

In sum, relatively small differences in initial conditions may put households and communities on diverging paths towards strikingly dissimilar outcomes. For instance, a household fortunate enough to own a head of cattle may reach higher incomes with the manure and be able to invest in fertilizer use. Similarly, off-farm incomes may be the source of liquidity that allows households to invest in intensification (Reardon 1997).

2.2 Agricultural intensification in Rwanda

This section does not discuss either the current policy on agricultural intensification or the evolution over time of agriculture development in Rwanda. It just

reviews briefly the literature that directly relates to the subsequent understanding of agricultural intensification in Rwanda, implicitly highlights the challenges that policy makers face and gives a brief explanation of how this paper makes a contribution to the understanding of fertilizer use in Rwanda.

The GOR through the Ministry of Agriculture completed in the late 90s the formulation of the agricultural strategy that focused, among other things, on: (a) the intensification of agriculture through complete restructuring of input provision services, (b) support to farmer groups in order to strengthen farmers' participation in technology generation and dissemination, (c) institutional reforms for enhanced extension and research services, (d) the rehabilitation of traditional export crops for greater competitiveness, (e) the rehabilitation of marshland and hillside farming to achieve greater efficiency and sustainability of production and (f) the promotion of regional specialization, coupled with product and market diversification.

Jayne et al. (2001), citing Gugert and Timmer, note that structural transformation requires broad-based rural income growth, and a broad-based rural income growth is facilitated by relatively egalitarian distribution of rural assets within the small farm population. They observe that around 50% of the rural small farm population cultivates less than 0.15 hectares per capita in densely populated countries such as Rwanda and Ethiopia, and less than 0.3 hectares per capita in supposedly land-abundant countries such as Zambia and Mozambique. They then notice that without major changes in access to land the following processes in these countries are likely to continue: (1) farm sizes are likely to decline over time; (2) landlessness and near landlessness will emerge as increasingly important social and economic problems unless growth in the non-farm

sectors can be substantially increased; and (3) given existing agricultural technology and realistic projections of future productivity growth potential, large segments of the rural population will be unable to climb out of poverty through agricultural growth on their own.

Farmers everywhere have responded to land use pressure and concomitant declining productivity by intensifying agriculture and used new efficient technologies. Empirical research on intensification in Africa has illustrated two intensification paths initially described by Boserup (1965) and labeled by Clay et al. (1998) as capital-led and labor-led paths. In Rwanda capital farm inputs include (1) land conservation infrastructure, (2) organic inputs, and (3) chemical inputs.

Clay et al. (1998) using a nationwide sample of Rwandan farm households found that (1) the vast majority of farmers fall between the two extremes of the labor-led and the capital-led intensification paths in their pure form, (2) in general, investments in land conservation and fertility are greater on land owned (not rented) by farmers, where slopes are of medium steepness, where land is less fragmented and is cultivated for a shorter time, and on small farms and those with little land in fallow, woodlot, and pasture, (3) nonfarm income affects farm investment and enhances the capacity of households to follow the capital-led intensification path, (4) short-term relative economic profitability of cropping, commercialization, lower price risk, and more accessible infrastructure promote the use of organic and chemical inputs to enhance soil fertility, and (5) the knowledge farmers gained from extension encouraged sustainable production practices, specifically the use of organic matter and the building of terraces.

Along with the landholding and household-level intersectoral links, issues that need strong and appropriate policy, agricultural intensification in Rwanda is determined by differences in the capacity to invest. As partially mentioned in a previous section, Kelly et al. (2001a and 2001b) found that the most common reason of not using inorganic fertilizer in Rwanda is the lack of knowledge and the next most common is the high fertilizer prices. The interpretation they give to the first reason is that farmers' knowledge of the benefits and of how to use the fertilizers is not strong enough to stimulate use. The second reason is more related to investment constraints than to fertilizer prices per se. In fact, in Kelly and Murekezi. (2000), results on fertilizer value/cost ratios show that commodities such as maize, sorghum, Irish potato, sweet potato and cabbage show profitable returns to fertilizer in one or more agro-ecological zones of Rwanda. However only Irish potatoes are grown with mineral fertilizer by many farmers in Rwanda, especially in the northwestern provinces, mostly in Ruhengeri and Gisenyi.

CHAPTER 3

BACKGROUND ON AGRICULTURE IN KIGALI RURAL PROVINCE

In this chapter, especially in its second part, data are analyzed from two recent surveys on nationwide stratified-random samples. The Ministry of Finance and Economic Planning implemented one of them, the Rwandan Integrated Household Living Condition Survey (EICV) between July 2000 and July 2001. The Food Security Research Project (FSRP) conducted the other one, the seasonal agricultural production surveys, from the agricultural year 2000 to the agricultural year 2002, on a sub-sample of the EICV survey.

3.1 Physical environment

The Kigali rural province has five natural regions, the hautes terres du Buberuka (5B), the plateau central (4D), the plateau de l'Est (4F), the Bugesera (6A) and the Mayaga (6B) (Berdinger 1993). The first one represents just a small portion of the province and has very little economic role for the Kigali rural province. The last two are most of the time taken together given their similarities in term of agricultural crop production systems. Hence, three agro-ecological zones, that is, Bugesera/Mayaga zone, Plateaux de l'Est and Plateau central, are of major interest and constitute focal points of different analyses in this study.

3.1.1 General Characteristics

The Bugesera agro-ecological zone is a region with less fertile soils (xerokaolisols) on plateaus separated by small lakes and wetlands. Plateaus are covered by dry shrub savannahs. The altitude varies between 1,400 and 1,500. The annual average rainfall is about of 900mm, with contrasting dry seasons and rainy seasons, but irregular from year to year, with very long dry periods.

The plateau de l'Est zone is characterized by mean altitude of 1500m, mean rainfall of 1000mm, and deep soils with medium to good nutrient levels. Two dry seasons (mid-June to mid-September and December-January) alternate with two rainy seasons. Mean temperatures vary between 19 and 22.5 C degrees and are stable through the year.

The plateau central is a zone whose altitude varies from 1460 m to 2250 m with steep slopes that cause severe soil erosion. Clay-sandy soils, most of the time laterites, are in general less deep and highly impoverished in nutrients because of the erosion. Rainfall is an average of 1100mm/year, varying from 1000 to 1300mm/year.

3.1.2 Agricultural calendar

The agricultural year has two major seasons, season A (September-February) and season B (March-July) (Table C-1). A third one that takes place during the June-August dry season concerns crop production in marshlands. The agricultural calendar presented in this section considers mostly crop production during the two major seasons for the three major agro-ecological zones in Kigali rural province. Furthermore, for a semi-subsistence agriculture where the farming system is characterized by mixed crops and no specialization in crop production, the farmer produces a number of crops that can be grouped in major, intermediate and minor crops, in terms of area allocated on each crop.

3.2 Household assets

The farm is described in this section in term of demography, landholding and use, and crop production.

3.2.1 Human resources

In a semi-subsistence rural economy as is the case for Rwanda, the size of the household, the gender and age of the head of the household, and the level of education of the household head are some of the very important characteristics of the farm.

3.2.1.1 Household population

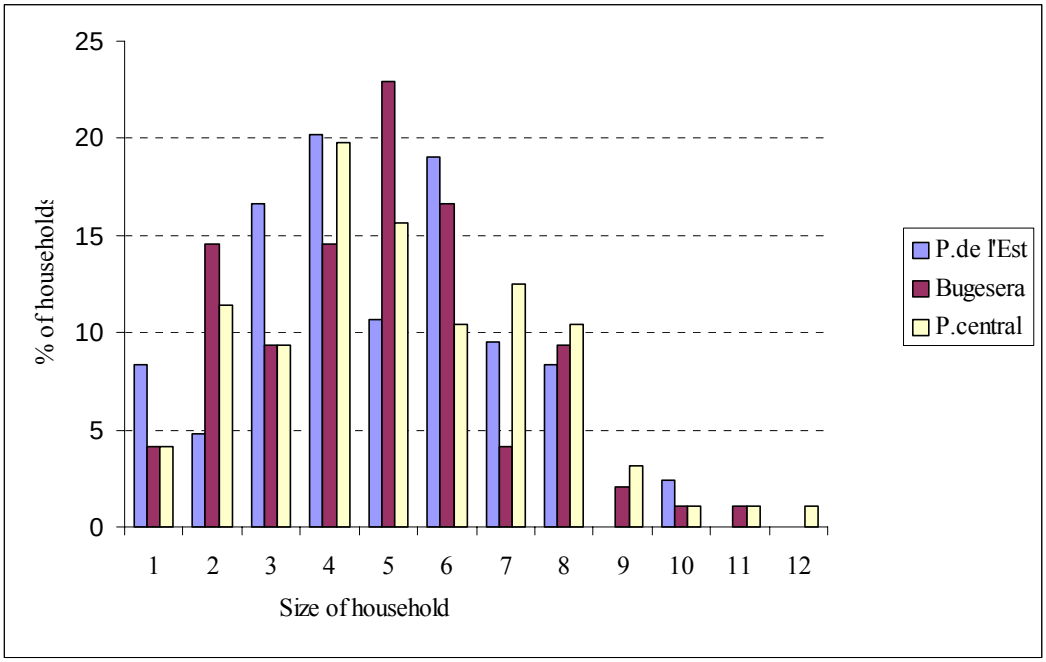
A average household in Kigali rural province has approximately 5 people (Table 3-1). Figure 1 shows explicitly that most of the farms have a size of 2 to 8 people and the aggregate of those with 3 to 6 people constitutes more than 50% of total households. This is very important in the context of shortage of land. When land is scarce, as the size of the household increases, competition for land use between food crop and cash crop increases and the result is a decrease in household cash income.

Table 3-1: Mean household size in the three major agro-ecological zones

	Mean household size	Mean adult equivalent
Plateau de l'Est	4.7	4.3
Bugesera	4.8	4.3
Plateau central	5.1	4.6

Source: Computed from EICV data/ MINECOFIN survey (July 2000 – July 2001)

Figure 3-1: Distribution of households (percent of households per category of household size), Kigali rural, Rwanda, 2001



Source: Generated from EICV data/ MINECOFIN survey (July 2000 – July 2001)

3.2.1.2 Household head characteristics

A. Age and gender of the household head

The nongovernmental organization "Human rights watch" (2001) notes that following the 1994 war in Rwanda, a substantial number of heads of household are drawn from vulnerable sectors of the society, that is, women, children, and elderly. Figures in table D-1 confirm that observation for Kigali rural province. The Plateau central agro-ecological zone has both the highest proportion of female-headed households and the highest elderly-headed households.

The comparison of the 2001 data (Table D-1) to those of a study done in the early 1980s reveals a substantial increase of female-headed households. A socioeconomic study for the region of Bugesera (MINAGRI 1981) found that 93% of households were headed by males, suggesting a decrease of about 30% compared to the 63% of households headed by male in 2001. The proportions of elderly household heads are in the same range (9% for 1981 and 11 for 2001) but diverge for the gender of those household heads. In 1981, 7 out of the 9% were male whereas in 2001, 8 out of the 11 % were females.

B. Level of education of the household head

The proportion of illiterate household heads is more than 50% (Table D-2) in the three agro-ecological zones and constitutes a very big constraint to the diffusion and adoption of improved technologies. These results show also that the proportion of female illiterate households is relatively high compared that of male household heads. From 100 households in the plateau de l'Est agro-ecological zone, 40 of them are headed by female and 37 out of those 40 females are illiterates whereas only 17 out of the 60 male

household heads are illiterate. The proportion of female illiterate household heads is lower in the two other agro-ecological zones but still higher than that of males.

3.2.2 Household landholdings

Rwanda and in particular Kigali rural province has limited natural resources, including a shortage of land due to the mostly hilly and mountainous terrain and costly-to-use wetlands. According to the EICV results, on average, 79.4% of households in Rwanda own some farmland (MINECOFIN, 2001). The practices of land renting, share cropping and lending are common in Kigali rural province.

3.2.2.1 Size of household landholdings

The average farm in Kigali rural province (1.22 hectares) is higher than the average at the national level (0.86 hectares) (Table D-3), with some variation by agro-ecological zone. The largest average farm size appears in Plateau central, with the smallest in Bugesera.

The land distribution patterns shown by the data in table D-3 and D-4 indicate that land is somewhat concentrated in the upper income quartile households. On a per farm basis, the upper 25% (large landowners) of households hold 61 and 54 percent of land, respectively, at the national level and in Kigali rural province. A very similar pattern persists even when the size of the household in terms of adult equivalents is taken into account (Table D-4). Within the Kigali rural province the same trend is observed across the agro-ecological zones. The fourth quartile of households (large landowners) holds 47%, 52% and 62% of land, respectively in Bugesera, plateau de l'est and plateau central agro-ecological zones.

For the lowest quartile of households (small landowners), the farm size is very small, on average about one-third of a hectare in Kigali rural province and less than one-fifth at the national level. The first quartile of households (small landowners) in the three agro-ecological zones of Kigali province hold less than 10% of land when we consider both the land area farmed by a household (Table D-3) and the land area farmed by an adult equivalent (Table D-5).

The Plateau central agro-ecological zone has both the highest average farmland area per household (1.58 hectares) and average farmland area per adult equivalent (0.35 hectare) (Tables D-3 and D-4).

3.3 Crops

3.3.1 Crop productions

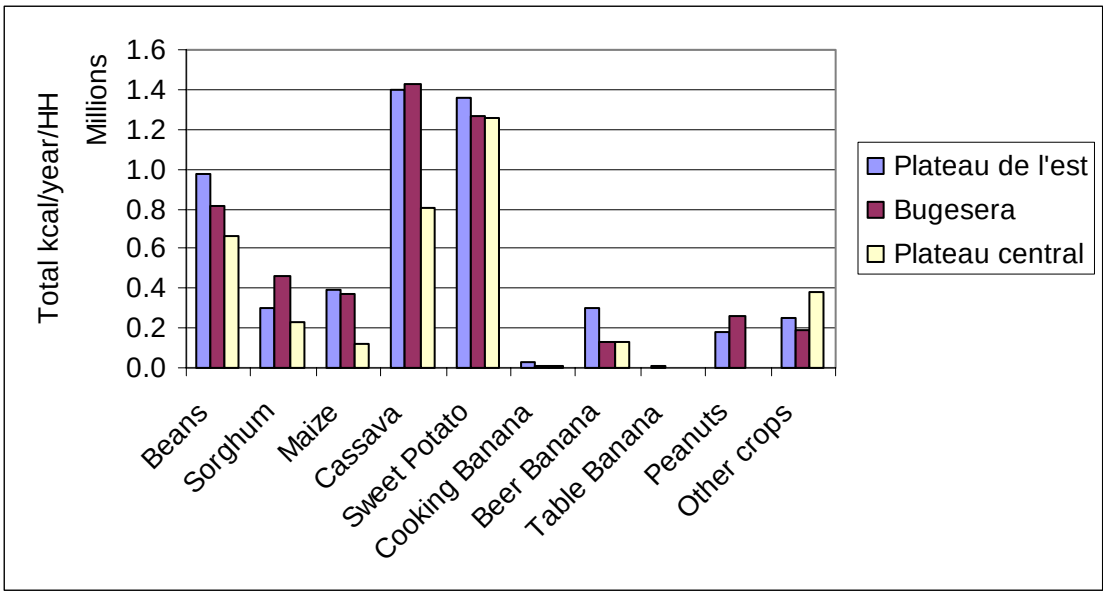
As said in a previous chapter, Rwanda has two main agricultural seasons per year, although bananas, roots and tubers, and to some extent other crops are harvested throughout the year. Figure 3 shows the Kigali rural province mean production estimates per year of major crops and some minor crops during three agricultural years (2000 – 2002). For cross-crop comparability, all production is expressed in terms of food energy.

Cassava and sweet potato contribute 53%, 54.6% and 57.3% of total household food energy, respectively, for plateau de l'est, Bugesera, and plateau central agro-ecological zones. Beans constitute the third contributor to the household food energy just before sorghum and maize in plateau de l'est and Bugesera, and before sorghum and minor crops all together in plateau central agroecological zone (Figure 3-3).

Compared to the needs of the average household (10,330 kcal)[5], household crop production in the Plateau de l'Est and Bugesera/Mayaga cover all the needs of the household, suggesting that the household has some extra production for the market (Figure 3-4). On the other hand, a household in the Plateau central zone has to buy some food on the market as a complement to its own production since it produces less than what is needed.

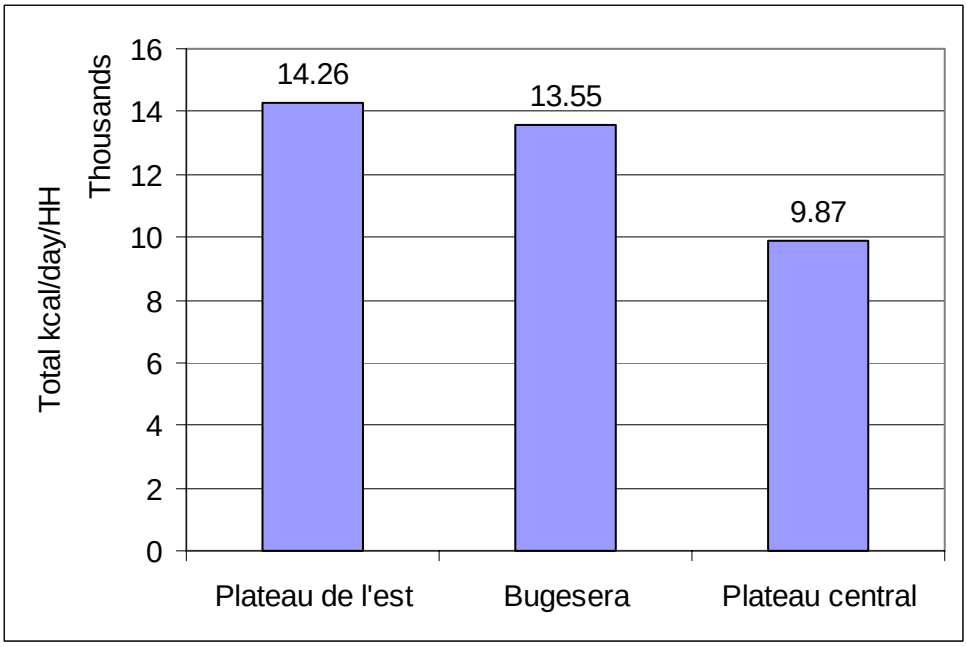
[5] The coefficients used to compute the needs of the average household (5 people) are: 2600 kcal for a male of 10 years old or more, 2350 for a female of 10 years old or more, 2190 for a child of 7 to 9 years old, 1830 for a child of 4 to 6 years old and 1090 for a child of 1 to 3 years old (MINAGRI 1981)

Figure 3-2: Annual crop production (in kcal) per household for main crops in Kigali rural province, Rwanda, Average 2000-2002.



Source: Table E-7

Figure 3-3: Total energy produced, available per day per household in the three major agricultural zones in Kigali rural province, Rwanda, Average 2000-2002.



Source: Table E-7

3.3.2 Patterns of land use by farm size

When comparing land use by household farm size in the context of scarcity of land, one expects that the main difference between small and large farmers is the much larger share of small farmers' land that is under crops. In fact, it is considered that for a country like Rwanda, pasture and fallow are "luxuries" for large farmers. However, it is true also that some farmers resort to fallowing not because they have much land but because their fields are so poor that they yield little without fallowing.

The definition of cultivable land used in tables E-1 to E-3 excludes pasture and woodlots but includes fallow. In Rwanda, the woodlots that remain on farms are mostly located on steep slopes and on other marginal lands whereas land that is only used as pasture is in general marginal land owned by a household that has some cattle.

There is not really any pattern of land use by farm size in the three major agro-ecological zones of Kigali rural province (tables E-1 to E-3). The proportion of land allocated to different categories of crops lies in the same range for small and large farmers with some exceptions.

As said in a previous paragraph, the 19% and 24% of land under fallow, respectively, for the lowest and the highest farm size quartile could have different meanings. In fact, according to the Boserupian theory one would expect to observe less and less land under fallow as the land area farmed decreases. To some extent, however, the quasi-absence of pasture and woodlot reflects that theory.

The large proportion of land allocated to legumes and roots and tubers reflects the food habits in Rwanda in general and in the Kigali rural province in particular. The land share of banana is on average less than 10% of cultivable land in Bugesera zone, making banana the fourth crop in that zone whereas it is in the top three in the two other major

agro-ecological zones. The low land share of banana is not explained by the incompatibility of the ecological conditions to that crop but by the destruction of the banana plantations by a two-year drought.

Compared to the two other agro-ecological zones, the Plateau central has two particular aspects. First, as one would expect, the proportion of cultivable land under crop decreases with the increase of land available per adult equivalent. Second, a quite high proportion of land is used for woodlots. The plateau central is a region with steep slopes and hence with more land not suited for crops.

In table E-4 to E-6 legumes, cereals and roots and tubers are disaggregated in specific showing the main crops in terms of proportion of land allocated to each one of them. The percentage of cultivated land is used in these tables instead of cultivable land which is used the three preceding tables.

Beans constitute the major legume in the three major agro-ecological zones. Other legumes are almost nonexistent in plateau de l'est zone. Peanuts and soybeans are grown in Bugesera but at a very low land share whereas peas constitute the second legume after beans in the plateau central zone.

Cereals in Kigali rural province include sorghum and maize. Sorghum has the lion's share of the land allocated to cereals in the three agro-ecological zones. Maize is not a staple food in Kigali rural province and in most other provinces in Rwanda. The maize share of cultivated land is on average less than 5%, whereas the average sorghum share is more than 10%, in Kigali rural province.

Roots and tubers include two major crops, sweet potato and cassava and, two minor crops, white potato and taro (colocasia). One-fifth of cultivated land is allocated to

cassava in Bugesera zone (table E-5) making it the second most important crop in that zone, after beans. The importance of cassava in the three major agro-ecological zones of Kigali rural province is mostly explained by the fact that it provides higher income returns than other crops on less fertile soils.

CHAPTER 4

CROP BUDGETS: ELABORATION AND ANALYSIS

A crop budget lists all income and costs of a specific crop to provide an estimate of its profits. Crop profits are expressed in terms of gross or net margin. Calculations are developed on a single common unit, in general the "hectare". A crop budget allows not only comparison of profitability among different crops on the same farm but also comparison of profitability of a given crop under either different levels of the same single technology or different technologies.

In this chapter crop budgets are elaborated for the three major agro-ecological zones of Kigali rural province. Climbing beans, maize, sorghum and soybeans budgets are elaborated for both the plateau central and plateau de l'est agro-ecological zones whereas only sorghum budgets are elaborated for the Bugesera zone.

4.1 Elaboration of crop budgets

4.1.1 Technical modules

Two major types of modules are distinguished:

- Traditional module

This module represents the traditional mode of production. Fertilizer consists of compost and/or animal manure used most of the time at a very low level, compared to what research recommends. Seeds are mostly from farmers' own production, sometimes bought from other farmers in local markets. This module is almost the only one used by farmers in Kigali rural province.

- Improved techniques

This module corresponds to the use of organic and chemical fertilizer, pesticides, improved seeds and other improved cultivation techniques. This module is almost nonexistent on land area farmed by individual farmers. It appears mostly in lands used by farmer associations that get inputs from rural development projects as loans.

4.1.2 Agricultural inputs

The costs of small agricultural equipment, seeds, fertilizer, crop protection products and labor were incorporated in the budgets. The seasonal cost of small agricultural equipment (tools) was estimated in two steps. Assuming that for a hectare of a crop a given number of tools can be replaced after three years of use, that number was estimated and then the associated cost was divided by six (six agricultural seasons in three years) to get the seasonal cost. Labor cost was evaluated using the wage of agricultural labor.

The cost of seeds, fertilizer and crop protection products were determined from their local market prices. For some crops such as beans and soybeans, household own-production is so low that the next season the household buys the seed in the local market, whereas households use in general seed from their own production for sorghum and maize. Beans and soybeans seeds are then classified as monetary variable costs when sorghum and maize seeds are considered as non-monetary variable costs. The costs of all improved seeds are monetary variable costs. Since there is no real market for improved seeds in Rwanda for the crops considered in this study, their costs per hectare were those used by the improved seeds project in Rwanda (ASSR), a government institution that produces and disseminate those seeds.

4.1.3 Yields

Traditional module yields were estimated from data collected by the Food Security Research Project on crop production and area cultivated. The survey was designed to be representative at the province level with the "cellule" as the survey unit, each cellule having twelve households. To estimate yields at a lower level than the province, that is, at an agro-ecological level, data from farmers in cellules falling in the agroecological zone within Kigali rural province were used. Considering the topography of Rwanda and the fact that households at the cellule level were randomly selected, crop yield estimates are likely to be close to the actual ones.

The yields for "improved techniques" were estimated from a study done in 1997 by an agricultural specialist of the Ministry of Agriculture, using FAO data (improved techniques based on NPK) (MINAGRI 1997) and from Kelly and Murekezi (2000) for improved techniques based on DAP. The first study came up with a range of yields that can be achieved using the fertilizer "NPK" for each crop at the national level, and average yields for low, medium and high fertility sites. In this study, crops in plateau de l'est and Bugesera were assigned medium average yields whereas plateau central zone was assigned low average yields, given the quality of soils in these zone mentioned in a previous chapter or the agronomic performance of specific crops (Sorghum in Bugesera zone). Kelly and Murekezi study has the fertilizer (DPA[6] + Urea) response for selected crops and agro-ecological zones in Rwanda.

Yields in these two studies are assumed to be higher than farmers' yields because of higher management, smaller plot size, precision in harvesting date, and better harvesting methods.

[6] Diammonium Phosphate

The yields from the above two studies were scaled down by 20% to approximate the yields that farmers can obtain on their farms. The difference between yields from experimental fields and those from farmers' fields in similar cropping conditions would be the basis for the scaling down. For example, if an experimental yield is 3000 kg/ha[7] and those from farmers' practice are 2700 kg/ha, the difference is 300 kg/ha, corresponding to a 10% reduction.

The lack of information that could be used to generate more accurate scaling down proportions and to estimate the probability of the occurrence of the yields constitutes the main reason for the conservative assumptions on yields for improved agricultural techniques.

4.1.4 Input and output prices

Input and output prices used in the budgets are average local market prices for the agricultural year 2000-2001, ignoring the seasonality of crop output prices in Rwanda, for practical reasons. Household labor was valued at a cost similar to the agricultural wage but reduced by 20% (to 240 Frw) to reflect the relative low percentage of off-farm agricultural and non-agricultural jobs in rural areas in Rwanda and the fact that a peasant usually works on his farm for a rate of return less than the wage paid to hired labor. As said in a previous section hired labor was valued using the agricultural wage.

In the traditional mode of production farmers use own-produced manure. However that production is far lower than required quantity for improved agricultural technology. It was then assumed that the two-thirds of the required manure for improved techniques would be bought by the household and is then considered as monetary variable cost.

[7] ha = hectare

4.2 Crop budget analysis

In order to identify the most profitable crops and technical modules at the farm level, crop margins were calculated on the basis of 2001 agricultural year input and output local market prices. Three crop margins (Crawford and Lambrecht, 1985) were calculated for each of the two modules in each of the three agricultural zones:

- The gross monetary margin, i.e., gross revenue minus monetary variable input costs;
- The total gross margin, i.e., gross revenue minus total variable input cost;
- The net margin, i.e., gross revenue minus total input costs.

All these margins were estimated on a per hectare basis and ranked in two ways. First, they were ranked for each combination of crop and zone to identify the more profitable module of the 2 or 3 considered. Second, the ranking was made including all crops and all technical modules for a given zone to find the most profitable crops and modules overall in that zone. These rankings aimed to give answers to two important questions:

- Is production intensification by fertilizer use financially attractive?
- Which crop gives the best returns to the combination of organic and mineral fertilizer?

The crop budget analysis considers three more criteria in this section:

- Remuneration rate, i.e., total gross margin divided by total variable costs;
- Returns to family labor per day, i.e., total gross margin (family labor cost not included) divided by the number of family man-days;

- Cost share, i.e., proportion of each cost item included in the budget in the total cost.

The remuneration rate, known also as "rate of return on capital," indicates the net benefit the farmer gets per unit of capital invested, after reimbursement of costs engaged in crop production, whereas the net revenue of family labor indicates the remuneration of a family man-day on the family land.

4.2.1 Crop budget analysis for Plateau de l'Est zone

Family labor constitutes the major cost item for almost all crops and modules, where its cost share is over 60% and 30% for the traditional modes of production and the improved modes, respectively (figures 4-4 to 4-7). Mineral fertilizer followed by sticks and organic fertilizer for climbing beans (figure 4-4), organic fertilizer for sorghum, soybeans and maize (figure 4-5 to 4-7) constitutes the second most important cost item with more than 20 % cost share except for soybeans. Since family labor is a non-monetary cost item, mineral fertilizer constitutes the critical factor in the improved crop production process in the plateau de l'Est agro-biological zone.

The importance of these cost items combined with the level of yield and the market price of the production determine the level of the remuneration rate and the returns to family labor. From the ten combinations of crops and modules, the remuneration rate, that is, the net returns the farmer gets per "100Frw[8] " invested after reimbursement of costs engaged in crop production, is negative for four (all the three beans/modules combinations and sorghum grown with NPK), almost zero for one (soybeans/traditional modes of production), less than 30Frw for three of them (soybean

[8] Frw = Rwanda francs (local currency)

and sorghum grown with DAP and sorghum without fertilizer) and more than 30Frw for two others (maize without and with fertilizer use) (figure 4-3). These results reveal that, compared to traditional modes of production, the use of chemical fertilizer improves the remuneration rate for soybeans and sorghum, in the plateau de l'Est agro-ecological zone. Soybean is however a minor crop with less than one percent land share in plateau de l'Est zone. Since this crop is one of the key commodities the GOR has chosen to achieve economic growth, more extension and education activities are needed for its promotion.

The above results are consistent with those of the three categories of margins in table 4-1 and figure 4-1 and the returns to family labor per day in figure 4-2. The four combinations of crop and module with the highest remuneration rate constitute also the four top combinations in terms of returns to family labor and rankings based on margins; all the four combinations exhibit returns to family labor per day greater than the agricultural wage, that is, higher than 300 Frw. The remaining combinations generate returns to family labor lower than the wage rate assumed acceptable by farmers when working on their own farms, except maize produced without any use of chemical fertilizer. Overall the use of fertilizer improves the margins. However, the crop that would give the best returns (in Frw) to fertilizer use is soybeans, which has the highest difference between the margin with fertilizer use and that without fertilizer.

The comparisons, first, between the traditional modes of production and improved agricultural techniques (based on chemical fertilizer NPK and DAP) and second, between the two chemical fertilizer treatments, show that:

- The margins from the traditional modes of production are in general lower than those from improved agricultural techniques;

- The use of DAP improves the margins for all the three crops on which it was applied whereas NPK improves only one of the three crops grown with it.

Results in table 4-2 show that margin analysis and v/c ratio give different results. First, climbing bean grown with DAP has the highest v/c ratio (3.8) but has negative total gross and net margins. Second, soybean has a higher v/c ratio than maize (2.3 vs. 1.3), but lower margins (especially total gross and net margins). Hence, based on v/c ratio fertilizer use is profitable for climbing bean and soybean but not for maize. Margin analysis, on the other hand favors maize against climbing bean and soybean though it shows that fertilizer use is profitable for both maize and soybean. These differences are due to the quantity of data used in each of the two analytical tools. As said in Chapter one, the v/c ratio approach uses the incremental gross revenue and costs associated with the technology being assessed. On the other hand, with the margin analysis approach, all the costs associated with the implementation of a technology are considered. The margin analysis approach, compared to the v/c ratio approach, is a better guide to profitability since it takes into account a more complete set of costs.

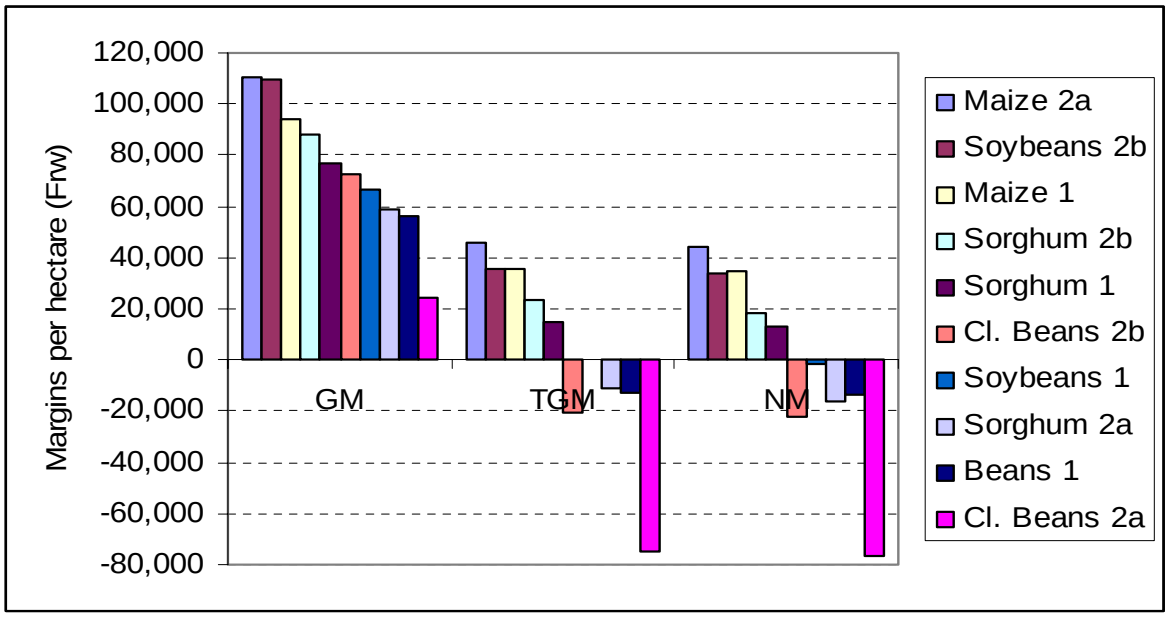
Table 4-1. Margin ranking in plateau de l'Est agro-ecological zone, Kigali rural province, Rwanda, 2001.

Rank	Gross Margin	Total gross margin	Net margin
1	Maize (Module 2a)	Maize (Module 2a)	Maize (Module 2a)
2	Soybeans (Module 2b)	Soybeans (Module 2a)	Soybeans (Module 2a)
3	Maize (Module 1)	Maize (Module 1)	Maize (Module 1)
4	Sorghum (Module 2b)	Sorghum (Module 2b)	Sorghum (Module 2b)
5	Cl. beans (Module 2b)	Sorghum (Module 1)	Sorghum (Module 1)
6	Sorghum (Module 1)		

Source: Data in table B-9

Note: Crops/modules with negative margins are not shown

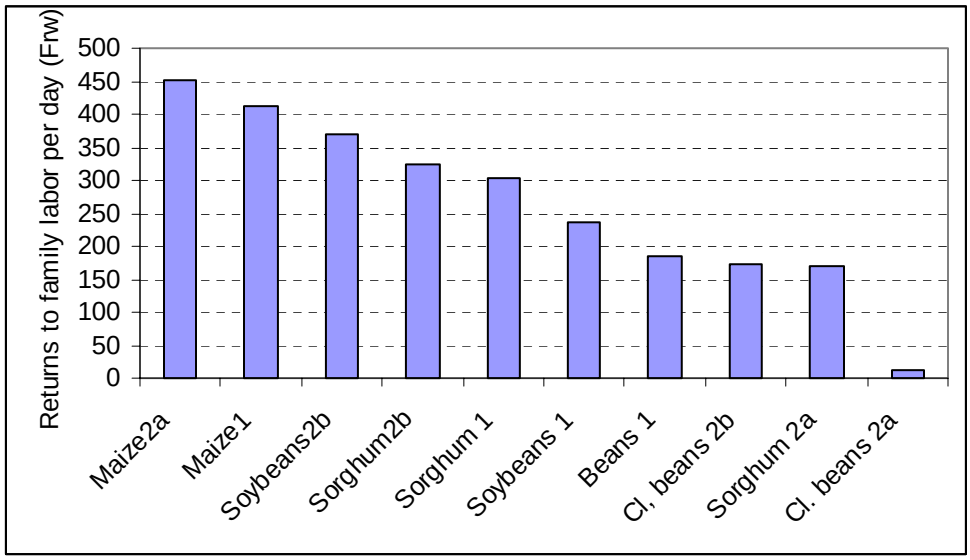
Figure 4-1: Margins in plateau de l'Est agro-ecological zone, Kigali rural province, Rwanda, 2001.



Source: Data in table B-9

GM= Gross margin
TGM= Total gross margin
NM= Net margin
1= Traditional mode of production
2a= Module 2 (improved techniques) with NPK
2b= Module 2 (improved techniques) with "DAP + urea"

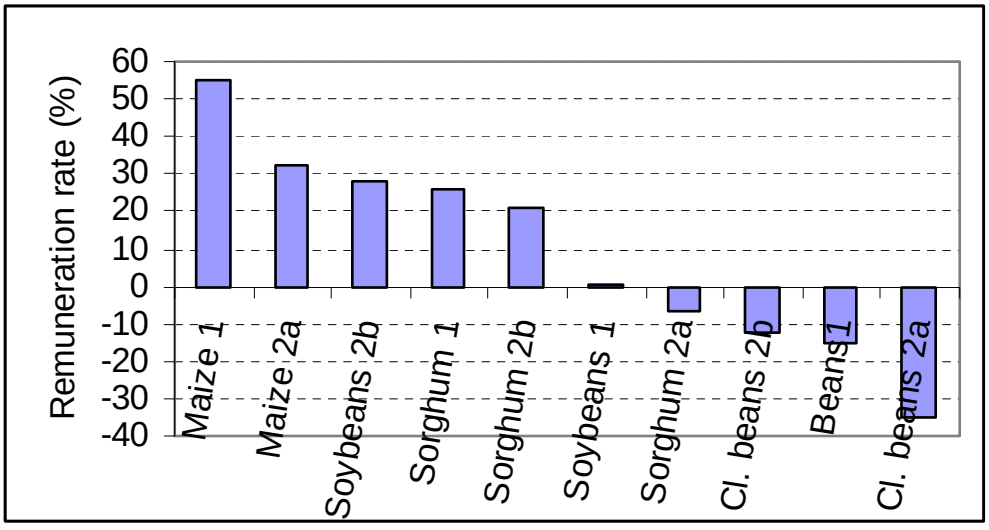
Figure 4-2: Returns to family labor (Frw) on household land for selected crops in plateau de l'Est agro-ecological zone, Kigali rural province, Rwanda, 2001.



Source: Data in table B-22

* Agricultural wage rate: 300 Frw per day

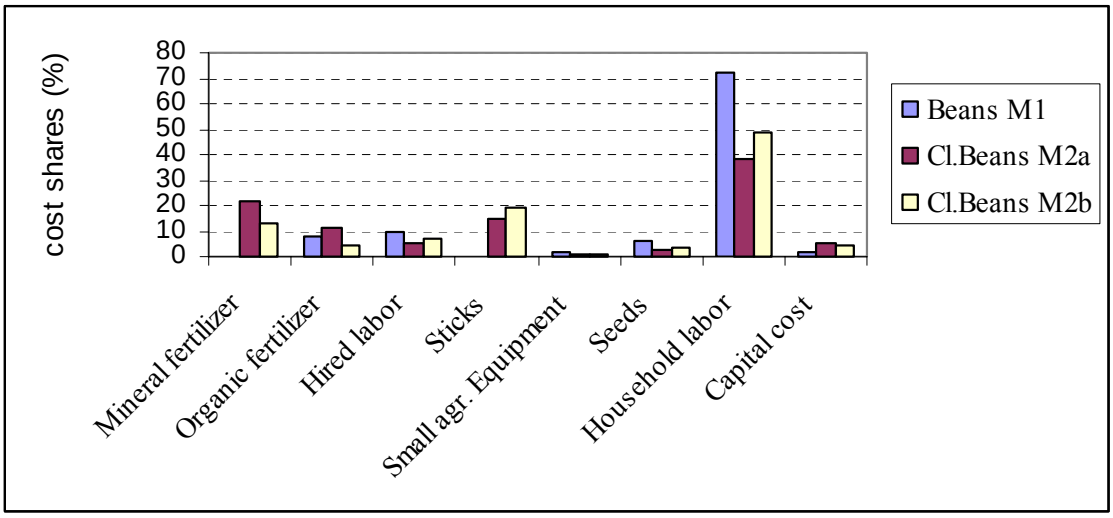
Figure 4-3: Remuneration rate for selected crops in plateau de l'Est agro-ecological zone, Kigali rural province, Rwanda, 2001.



Source: Data in table B-23

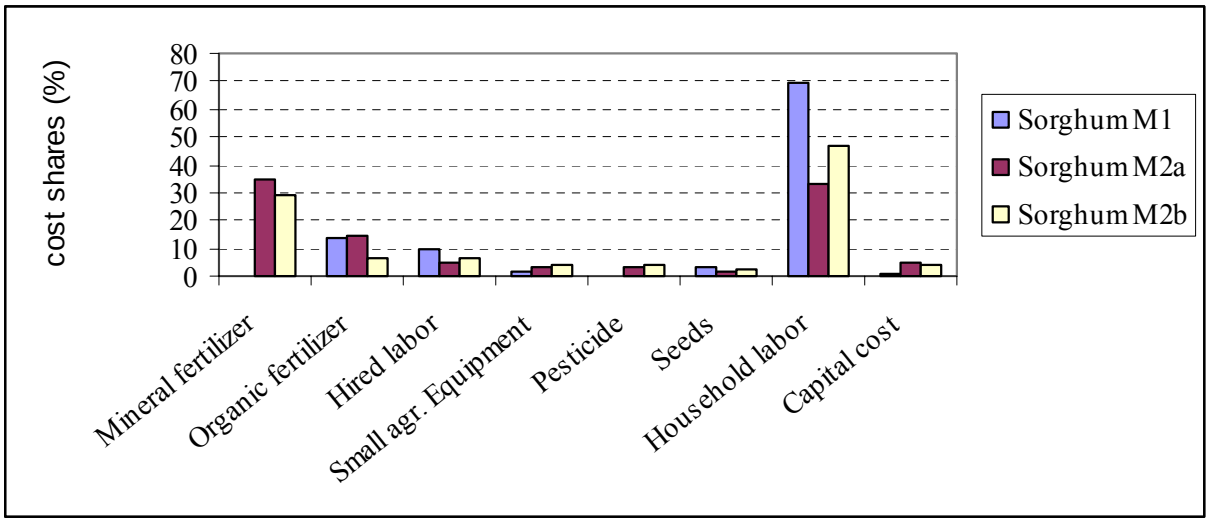
1= Traditional mode of production
2a= Module 2 (improved techniques) with NPK
2b= Module 2 (improved techniques) with "DAP + urea"

Figure 4-5: Cost shares for climbing beans production with traditional and improved practices in plateau de l'Est agro-ecological zone, Kigali rural province, Rwanda, 2001.



Source : Data in table B-10

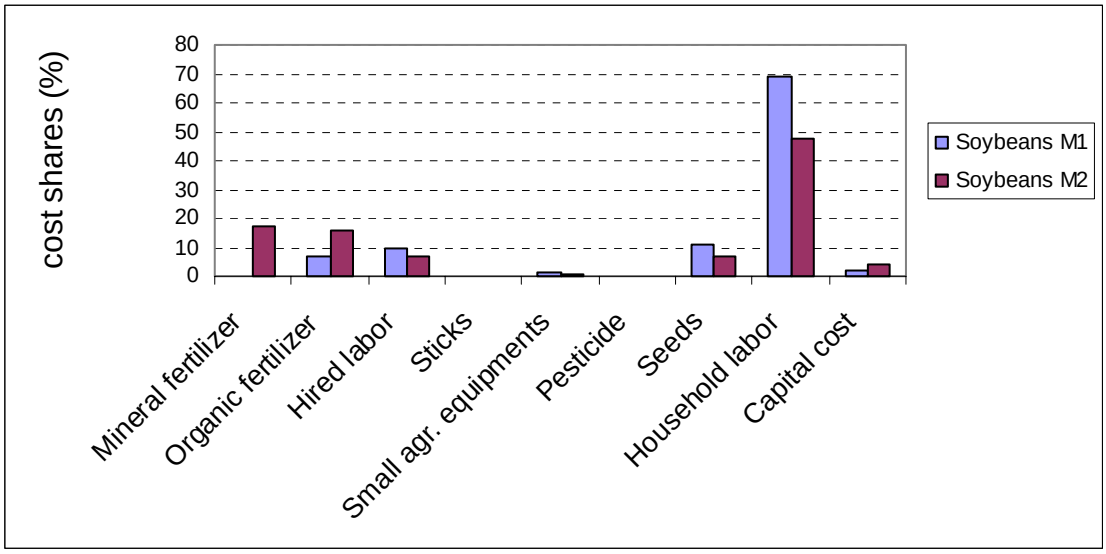
Figure 4-6: Cost shares for sorghum production with traditional and improved practices in plateau de l'Est agro-ecological zone, Kigali rural province, Rwanda, 2001.



Source : Data in table B-10

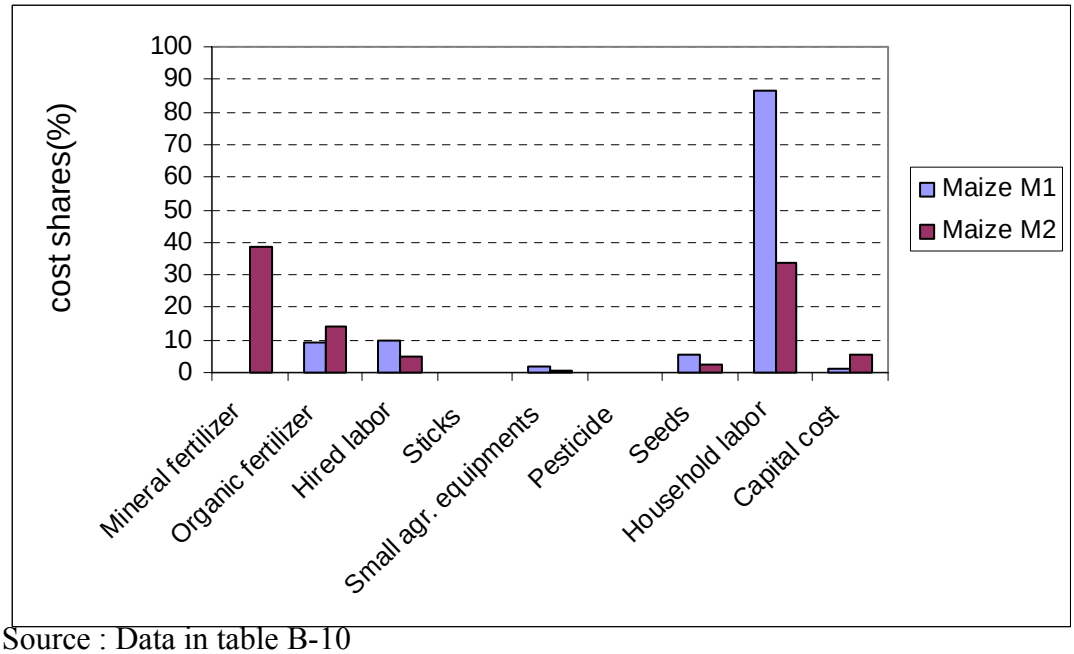
M1 = Module 1: Traditional modes of production.
M2 = Module 2: Improved agricultural technology techniques.

Figure 4-7: Cost shares for soybeans production with traditional and improved practices in plateau de l'Est agro-ecological zone, Kigali rural province, Rwanda, 2001.



Source: Data in table B-10

Figure 4-8: Cost shares for maize production with traditional and improved practices in plateau de l'Est agro-ecological zone, Kigali rural province, Rwanda, 2001.



Source : Data in table B-10

M1 = Module 1: Traditional modes of production.
M2 = Module 2: Improved agricultural techniques.

Table 4-2. Margins and v/c ratios in plateau de l'Est agro-ecological zone, Kigali rural province, Rwanda, 2001

	GM	TGM	NM	v/c ratio
Cl. Beans 2a	23,400	-75,790	-77,107	1.1
Beans 2b	72,620	-20,880	-22,197	3.8
Sorghum 2a	58,650	-10,745	-15,778	0.7
Sorghum 2b	88,102	23,284	18,251	1.6
Soybeans 2b	109,568	35,536	34,219	2.3
Maize 2a	110,538	45,831	44,514	1.3

Source: Table B-2, B-4, B-6 and B-8

4.2.2 Crop budget analysis for Plateau central zone

The analysis of the cost shares in the plateau central agro-ecological zone reveals the same trends as in the plateau de l'Est. Family labor, mineral fertilizer, sticks and organic fertilizer for climbing beans (figure 4-11), family labor and organic fertilizer for sorghum, and soybeans and maize (figure 4-12 to 4-14) constitute the most important cost items.

Cost items combined with the level of yield and the market price of the production in the plateau central agro-ecological zone lead to levels of the remuneration rate and the return to family labor far different from those observed in plateau de l'Est agro-ecological zone. From the eleven combinations of crop and modules, the remuneration rate the farmer gets per "100Frw[9]" invested after reimbursement of costs engaged in crop production, is negative for eight of them (all four selected crops when grown without fertilizer, all three crops grown with NPK and climbing beans grown with DAP), and positive and equal or less than 30Frw for the three remaining (sorghum, soybeans and maize grown with DAP) (figure 4-10).

The margins ranking shows that the above three combinations of crops and modules with the highest remuneration rate also have the highest margins, two of them (sorghum and soybean grown with DAP) being the only ones that remain positive at all three levels of margin (table 4-2 and figure 4-8). The last mentioned combinations constitute also the only ones that generate returns to family labor higher than the wage rate assumed acceptable by farmers when working on their farms, that is, 240Frws.

[9]Frw = Rwanda francs

The comparison between the traditional modes of production and improved agricultural techniques (based on chemical fertilizer NPK and DAP) and between the two chemical fertilizer treatments, shows that:

- The margins from the traditional modes of production are lower than those from improved agricultural techniques based on the use of DAP;
- DAP sole or combined with urea depending on the type of crop improves margins and the two other financial criteria whereas NPK in general decreases the magnitude of all the three criteria, compared to the traditional modes of production.

In plateau central, the two crop/module combinations (sorghum and soybeans grown with DAP) that exhibit higher margins have also higher v/c ratios (table 4-2). However, once again there is a conflict between the implications of the two criteria regarding on which of the two crops fertilizer is more profitable. Soybeans would be ranked number 1 based on v/c ratio criterion whereas it would be ranked second if we consider the magnitude of margins, sorghum grown with DAP being the crop with the highest margins.

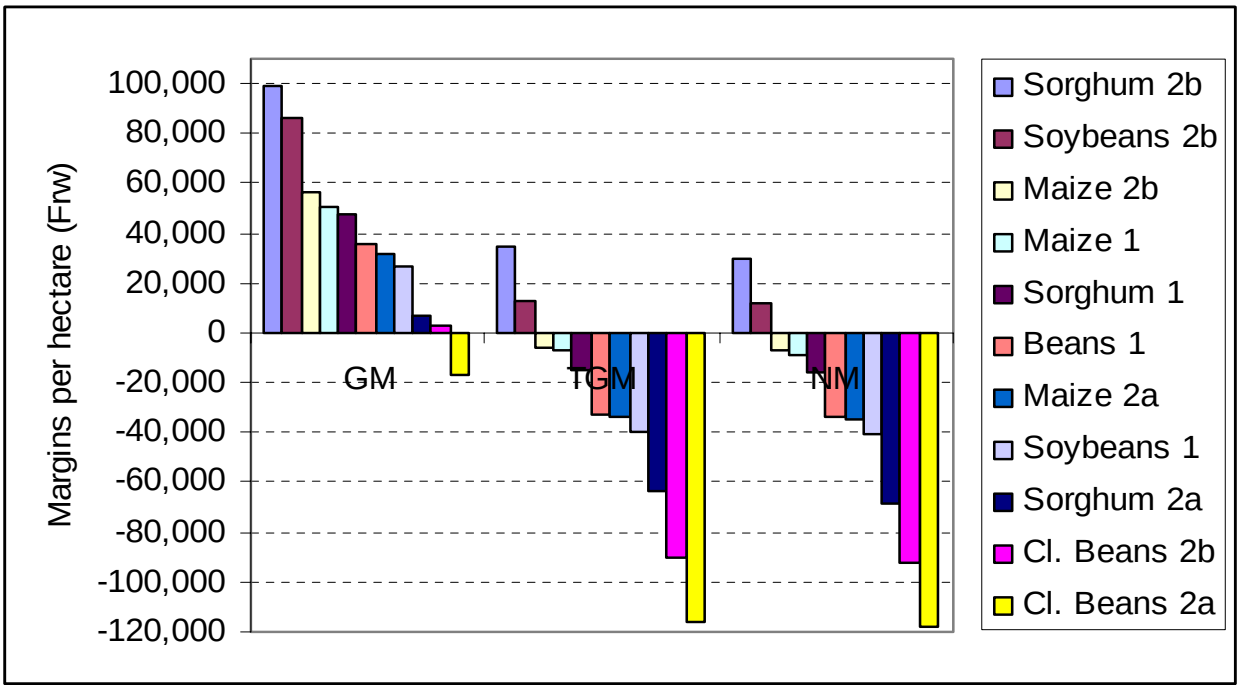
Table 4-3: Margin ranking in Plateau central agro-ecological zone, Kigali rural province, Rwanda, 2001

Rank	Gross Margin	Total gross margin	Net margin
1	Sorghum (Module 2b)	Sorghum (Module 2b)	Sorghum (Module 2b)
2	Soybeans (Module 2b)	Soybeans (Module 2b)	Soybeans (Module 2b)
3	Maize (Module 1)		
4	Sorghum (Module 1)		
5	Cl. beans (Module 1)		
6	Maize (Module 2a)		

Source: Data in table B-19

Note: Crops/modules with negative margins are not shown

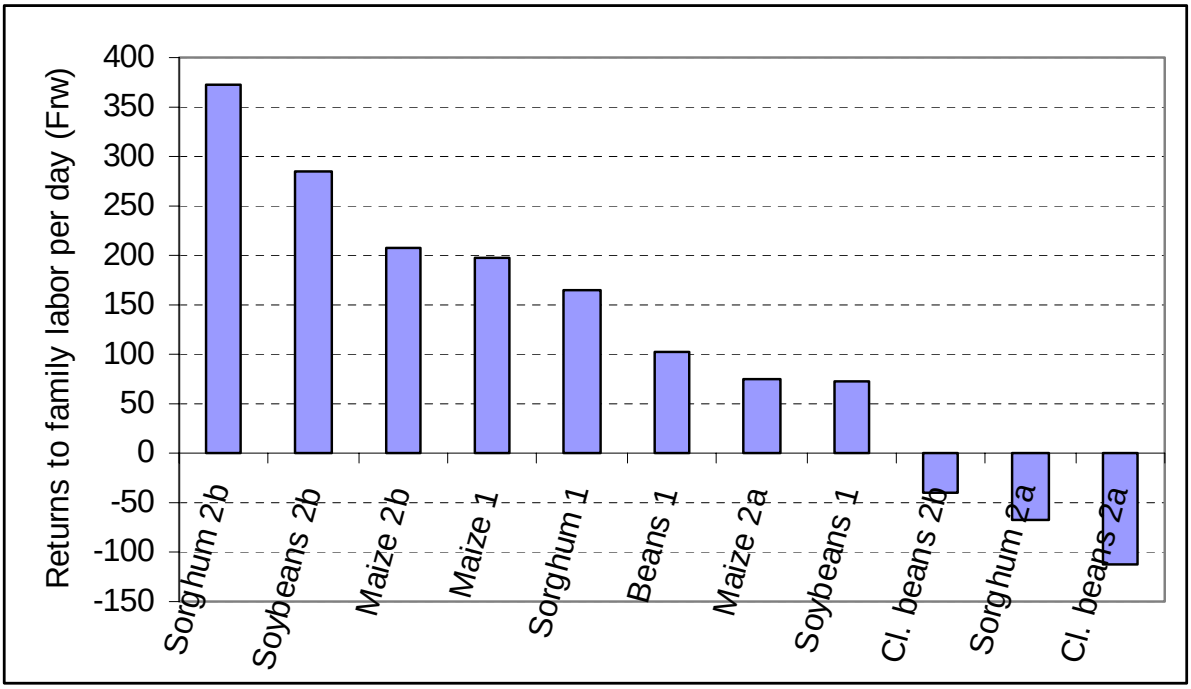
Figure 4-8: Margins in Plateau central agro-ecological zone, Kigali rural province, Rwanda, 2001.



Source: Data in table B-19

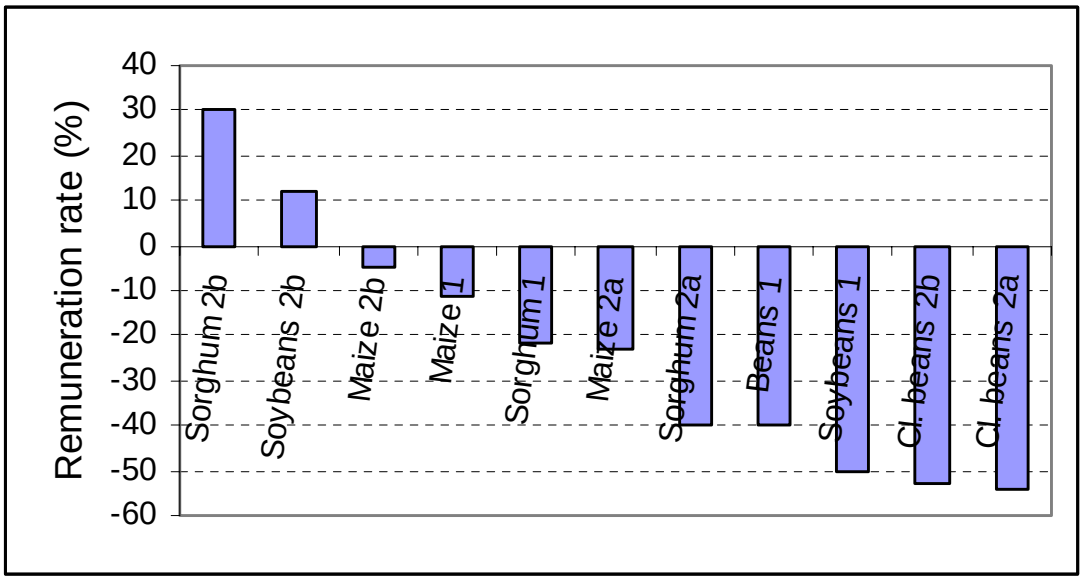
GM= Gross margin
TGM= Total gross margin
NM= Net margin
1= Traditional mode of production
2a= Module 2 (improved techniques) with NPK
2b= Module 2 (improved techniques) with "DAP + urea"

Figure 4-9: Returns to family labor (Frw) per day on household land for selected crops in plateau central agro-ecological zone, Kigali rural province, Rwanda, 2001.



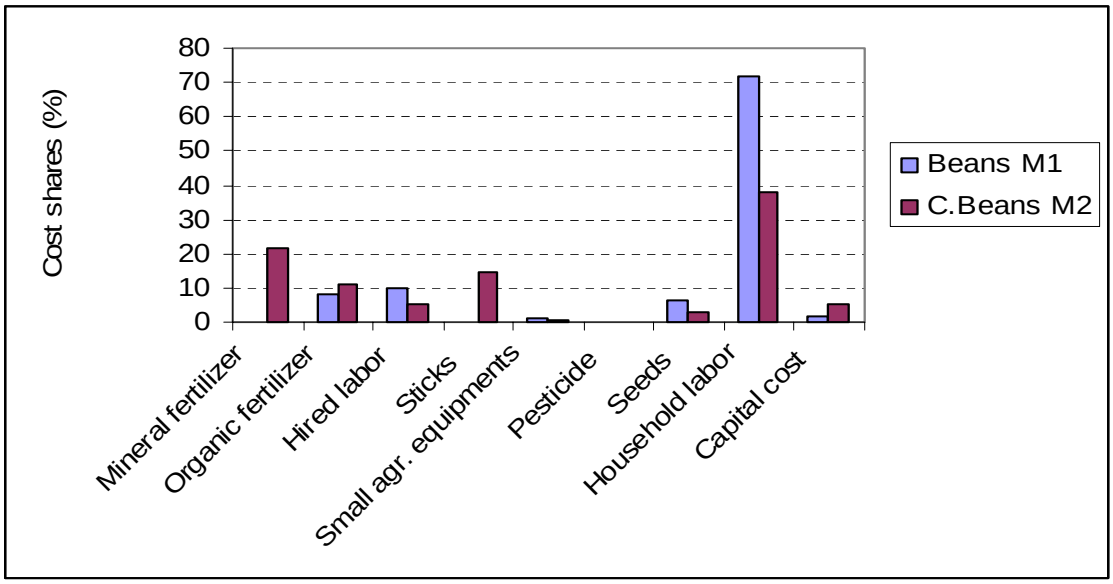
Source: Data in table B-22
* Agricultural wage rate: 300 Frw per day

Figure 4-10: Remuneration rate for selected crops in plateau central agro-ecological zone, Kigali rural province, Rwanda, 2001.



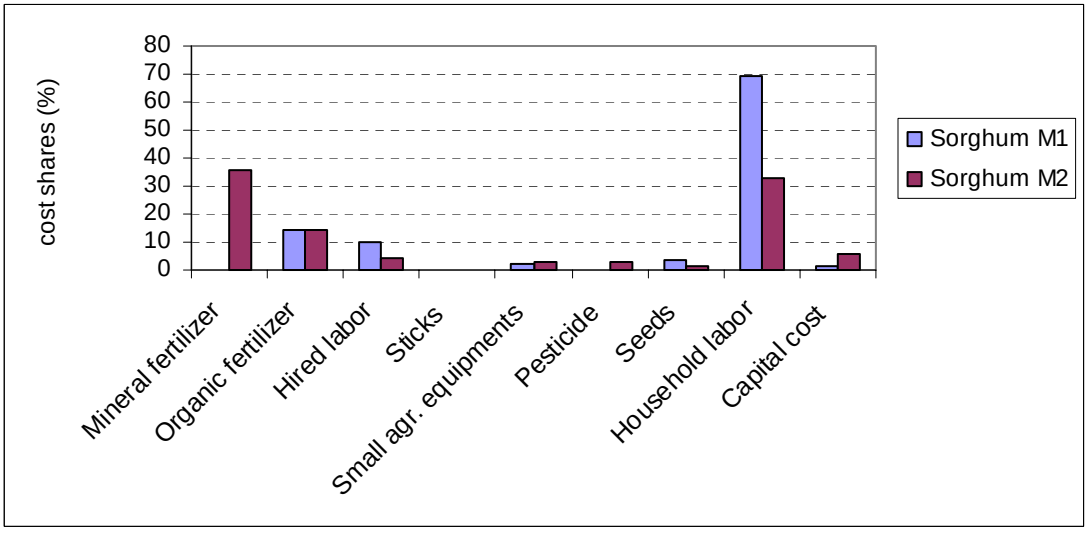
Source: Data in table B-23
1= Traditional mode of production
2a= Module 2 (improved techniques) with NPK
2b= Module 2 (improved techniques) with "DAP + urea"

Figure 4-11: Cost shares for beans production with traditional and improved practices in plateau central agro-ecological zone, Kigali rural province, Rwanda, 2001.



Source: Data in table B-20

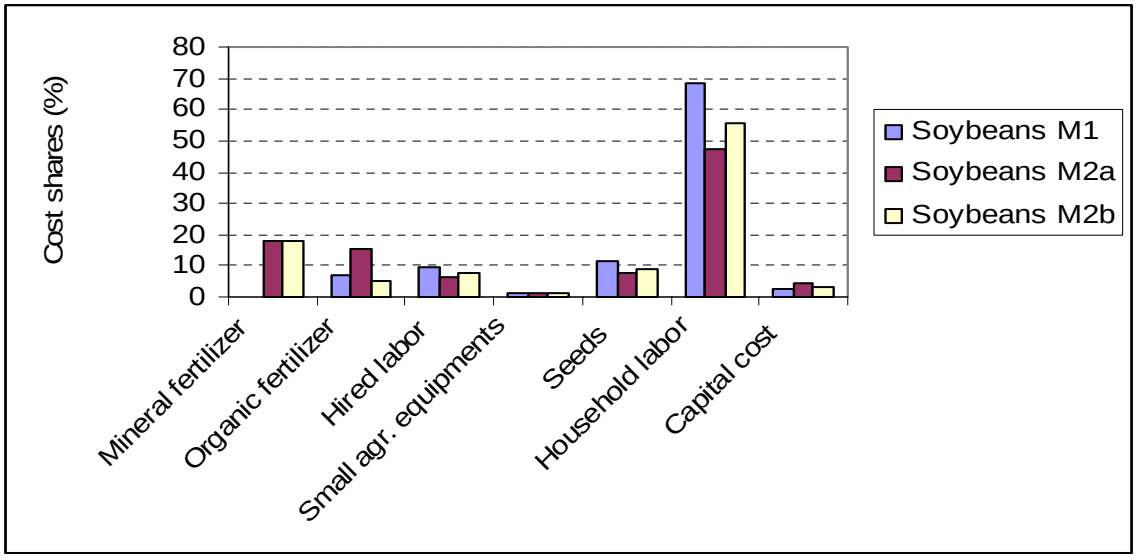
Figure 4-12: Cost shares for sorghum production with traditional and improved practices in plateau central agro-ecological zone, Kigali rural province, Rwanda, 2001.



Source: Data in table B-20

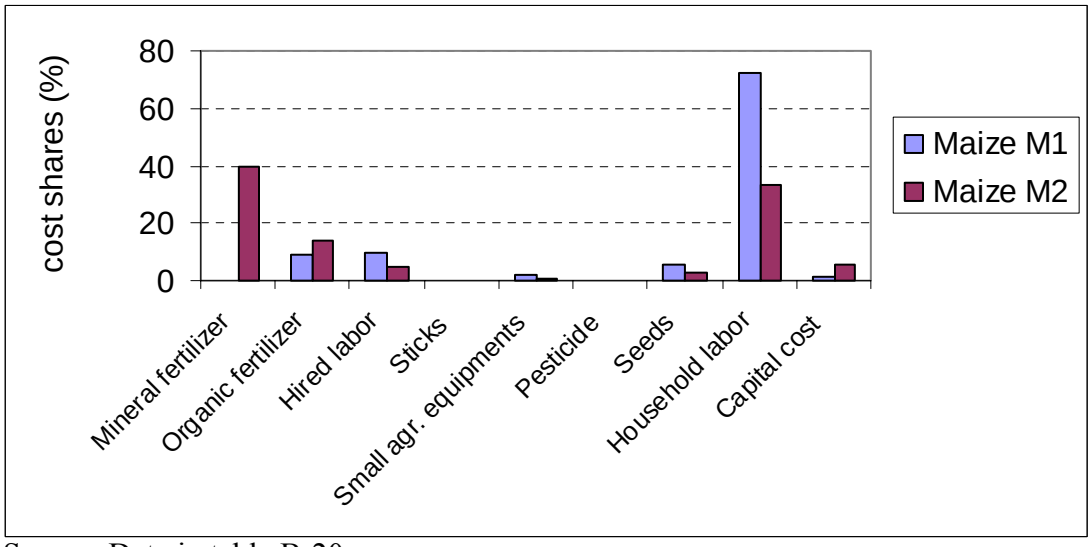
M1 = Module 1: Traditional modes of production.
M2 = Module 2: Improved agricultural technology techniques.

Figure 4-13: Cost shares for soybeans production with traditional and improved practices in plateau central agro-ecological zone, Kigali rural province, Rwanda, 2001.



Source: Data in table B-20

Figure 4-14: Cost shares for maize production with traditional and improved practices in plateau central agro-ecological zone, Kigali rural province, Rwanda, 2001.



Source: Data in table B-20

M1 = Module 1: Traditional modes of production.
M2 = Module 2: Improved agricultural techniques.

Table 4-4 Margins and v/c ratios in plateau central agro-ecological zone, Kigali rural province, Rwanda, 2001

	GM	TGM	NM	v/c ratio
Cl.beans 2a	-17,300	-116,490	-117,807	0.8
Cl. beans 2b	3,000	-90,600	-91,917	1.4
Sorghum 2a	6,502	-63,167	-68,200	0.6
Sorghum 2b	99,388	34,254	29,221	2.7
Soybeans 2b	85,876	13,331	12,014	4.3
Maize 2a	31,410	-33,543	-34,860	0.8
Maize 2b	56,476	-5,528	-6,84	1.2

Source: Table B-12, B-14, B-16 and B-18

4.2.3 Crop budget analysis for Bugesera /Mayaga zone

The analysis of the sorghum budget with the remuneration rate (figure 4-16), the returns to family labor (figure 4-17) and the margins (table 4-3 and figure 4-15) shows that the two fertilizer-based treatments, that is, NPK and DAP + Urea, have different outcomes on sorghum production in Bugesera/Mayaga agro-ecological zone. The first chemical fertilizer decreases the margins whereas the second (combination of DAP and Urea) improves the margins. For all three criteria the traditional modes of production are superior to the use of NPK but inferior to the use of the combination DAP and urea. The superiority of the traditional modes of production of sorghum over the improved techniques based on the use of NPK can partially be explained by the fact that the increase in revenue (61,920 Frws) is far less than the extra monetary variable costs (76,510 Frws) needed to generate it.

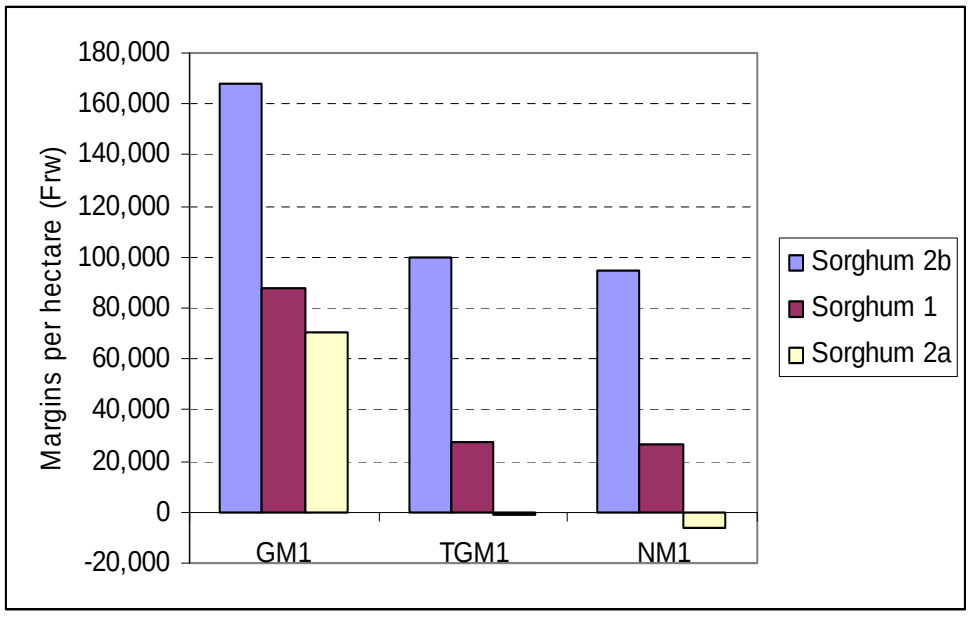
The comparison of margin analysis and c/v ratio criteria from the data in table 4-3 shows that the crop/module combination with highest margins (sorghum grown with DAP) has also the highest v/c ratio. The interpretation of figures would, however, have different meaning. With a v/c ratio fertilizer can be said to be moderately profitable whereas it would be highly profitable if we consider a net margin of 95,291 Frws per hectare.

Table 4-5: Margin ranking in Bugesera agro-ecological zone, Kigali rural province, Rwanda, 2001.

Rank	Gross Margin	Total gross margin	Net margin
1	Sorghum (Module 2b)	Sorghum (Module 2b)	Sorghum (Module2b)
2	Sorghum (Module 1)	Sorghum (Module 1)	Sorghum (Module1)
3	Sorghum (Module 2a)	Sorghum (Module 2a)	Sorghum (Module2a)

Source: Data in table B-23

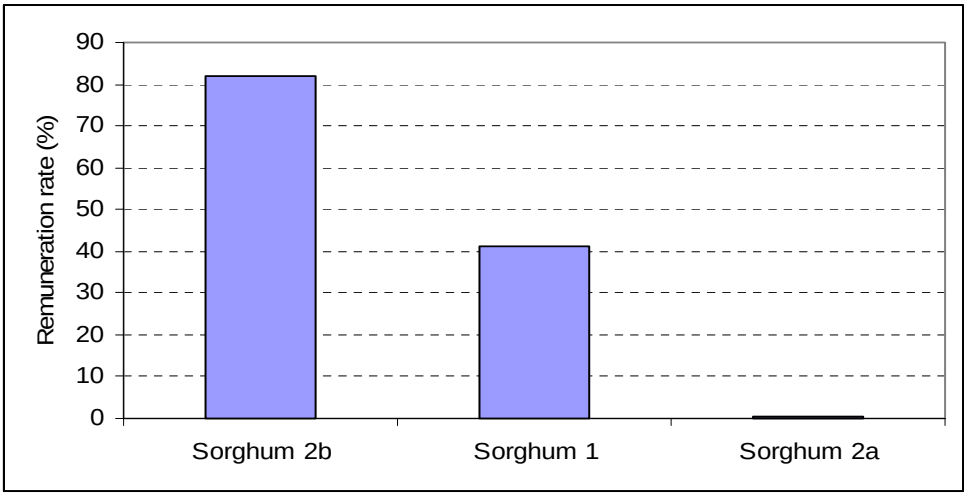
Figure 4-15: Margins in Bugesera agro-ecological zone, Kigali rural province, Rwanda, 2001.



Source: Data in table B-23

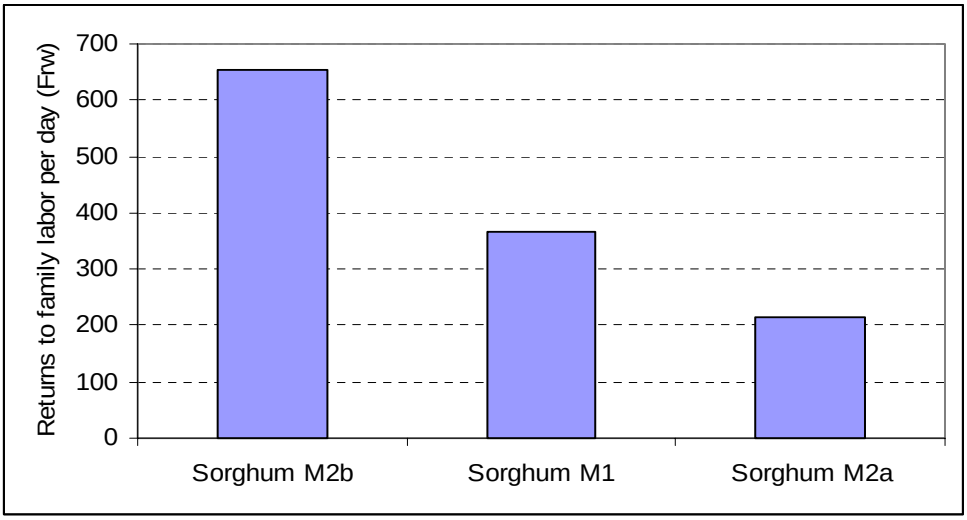
GM= Gross margin
TGM= Total gross margin
NM= Net margin
1= Traditional mode of production
2a= Module 2 (improved techniques) with NPK
2b= Module 2 (improved techniques) with "DAP + urea"

Figure 4-16: Remuneration rate for sorghum with traditional (M1) and improved (M2) practices in Bugesera/Mayaga agro-ecological zone, Kigali rural province, Rwanda, 2001.



Source: Data in table B-26

Figure 4-17: Returns to family labor (Frw) on household land for selected crops in Bugesera/Mayaga agro-ecological zone, Kigali rural province, Rwanda, 2001.

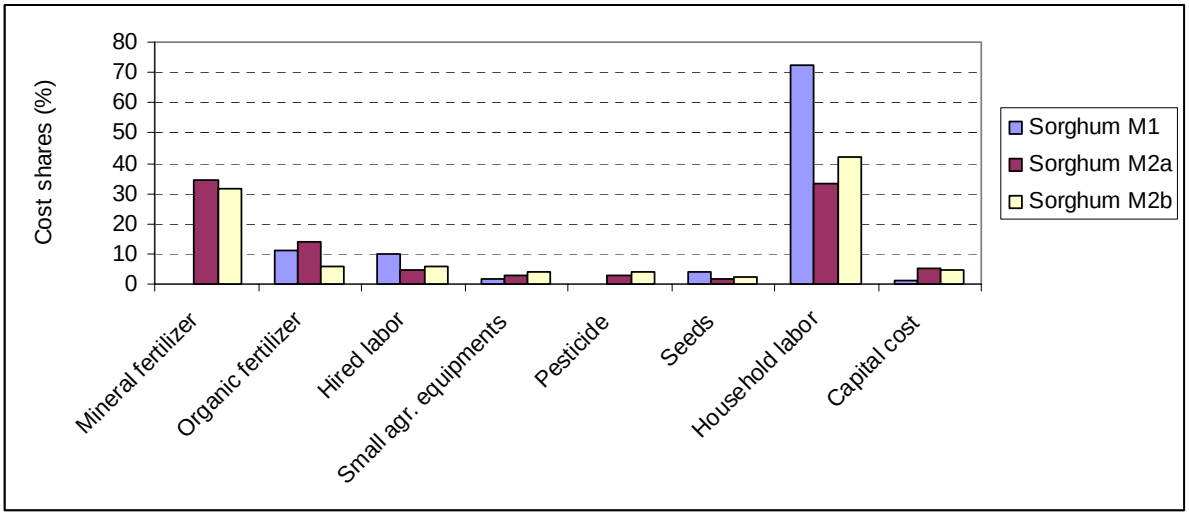


Source: Data in table B-25

Agricultural wage rate: 300 Frw per day

Notes: GM= Gross margin
TGM= Total gross margin
NM= Net margin
1= Traditional mode of production
2a= Module 2 (improved techniques) with NPK
2b= Module 2 (improved techniques) with "DAP + urea"

Figure 4-24: Cost shares for sorghum production with traditional and improved practices in Bugesera/Mayaga agro-ecological zone, Kigali rural province, Rwanda, 2001.



Source: Data in table B-21

Table 4-6 Margins and v/c ratios in Bugesera/Mayaga agro-ecological zone, Kigali rural province, Rwanda, 2001

	GM	TGM	NM	v/c ratio
Sorghum 2a	70140	-1438	-6471	0.9
Sorghum 2b	168,226	100,066	95,033	3.2

Source: Table B-22

Notes:
GM = Gross margin
TGM = Total gross margin
NM = Net margin
1= Traditional mode of production
2a= Module 2 (improved techniques) with NPK
2b= Module 2 (improved techniques) with "DAP + urea

4.3 Farm budgets

A Farm budget is a quantitative expression of the farm plan summarizing the income, costs, and profit. In the farm budget, the unit of analysis is the entire farm that may consist of several enterprises. A whole-farm budget is the one that includes all enterprises.

In this section, farm budgets are elaborated using the crop budgets discussed in the previous section. The budgets cover an area of 48 ares (0.48ha), which is the portion of a typical one hectare farm that allocated to the crops analyzed in this study (beans, sorghum, soybean, and maize). The average crop shares used in these farm budgets are averages at the province level whereas the gross revenues, costs and margins are from plateau de l'est zone crop budgets. A scenario with an increase of area for soybean against climbing bean is considered. Table 4-7 shows the margins and returns to labor for the two scenarios, using traditional modes of production.

Results in table 4-8 show that all things being constant for all enterprises not considered in the farm budgets, the use of fertilizer generates an incremental rate of return of 28%. An increase of the area allocated to soybean production from 1 are to 10 ares against a decrease of climbing bean from 30 ares to 21 ares, increases the incremental rate of return to 41%. It also increases the return per day of family labor. The substitution of bean by soybean can be motivated by the fact that both of them are legumes with high nutritional value. That substitution needs, however, support measures not only in terms of more extension and education to farmers but also in terms of soybean market promotion.

Table 4-7. Farm budget type for plateau de l'est zone (100ares): Traditional modes of production

	Scenario 1: Existing crop pattern				Scenario 2: Increased Soybean Area					
	Beans	Sorghum	Soybeans	Maize	Beans	Sorghum	Soybeans	Maize	Total S1	Total S2
Area cultivated (ares)	30	14	1	3	21	14	10	3	48	48
Gross revenue	21,090	11,760	838	3,013	14,763	11,760	8,380	3,013	36,701	37,916
Monetary variable costs	4,320	966	173	198	3,024	966	1,730	198	5,657	5,918
Non-monetary variable costs	20,538	8,758	665	1,744	14,377	8,758	6,650	1,744	31,705	31,529
Fixed costs	395	184	132	40	277	184	1,320	40	751	1,821
Gross margin	16,770	10,794	665	2,815	11,739	10,794	6,650	2,815	31,044	31,998
Total gross margin	-3,768	2,036	0	1,071	-2,638	2,036	0	1,071	-661	469
Net margin	-4,163	1,852	-132	1,031	-2,914	1,852	-1,320	1,031	-1,412	-1,351
Return to labor per day	184		235	413	184	316	235	413	238	247

Source: Tables B-1, B-3, B-5 and B-7
Note:
100 ares = 1hectare

Table 4-8. Farm budget type for plateau de l'est zone (100ares): Improved techniques

	Scenario 1: Existing crop pattern				Scenario 2: Increased Soybean Area					
	Beans	Sorghum	Soybeans	Maize	Beans	Sorghum	Soybeans	Maize	Total S1	Total S2
Area cultivated (ares)	30	14	1	3	21	14	10	3	48	48
Gross revenue	44,346	18,995	1,635	5,736	31,042	18,995	16,350	5,736	70,712	72,123
Monetary var. costs	22,560	6,661	539	2,420	15,792	6,661	5,390	2,420	32,180	30,263
Non-monetary variable costs	28,050	9,075	740	1,941	19,635	9,075	7,400	1,941	39,806	38,051
Fixed costs	395	705	132	40	277	705	1,320	40	1,272	2,342
Gross margin	21,786	12,334	1,096	3,316	15,250	12,334	10,960	3,316	38,532	41,860
Total gross margin	-6,264	3,259	356	1,375	-4,385	3,259	3,560	1,375	-1,274	3,809
Net margin	-6,659	2,554	224	1,335	-4,661	2,554	2,240	1,335	-2,546	1,468
Return to labor	172	323	371	451	172	323	371	451	238	275
Net Gain per hectare									7,488	9,862
Incremental Rate of Return									28	41
Change in Return to labor/day									0	28

Source: Tables B-2, B-4, B-6 and B-8

Notes :

100 ares = 1hectare

(1) Total Return to labor per day = (ΣReturn to labor per day $crop_i$ * Cultivated area $crop_i$)/Total cultivated area

(2) Net Gain per hectare = Gross margin Improved techniques – Gross margin traditional mode of production

(3) Incremental Rate of return = 100 * (GM_I - GM_T)/(Monetary variable $costs_I$ - Monetary variable $costs_T$)

(4) Change in Return to labor per day = Return to labor per day_I -Return to labor per day_T

CHAPTER 5

SUMMARY OF RESULTS AND POLICY IMPLICATIONS

The objective of this study was to evaluate the profitability of the main food crops in the context of the current government policy of promoting the use by farmers of improved inputs. This study tried to estimate the magnitudes of costs associated with the use of chemical fertilizer on climbing beans, maize, sorghum and soybeans grown in the province of Kigali rural and the benefits farmers would get by investing their labor and money in these crops. In less detail, this study analyzed some recent survey data seeking to put crop production in a wider perspective of the household's limitations and/or opportunities when dealing with the issue of improving crop yields on its land. This chapter first provides a summary of the major findings both on agriculture in Kigali rural province and on the crop budgets analysis, second, discusses policy implications briefly and, third, notes limitations of the study and suggestions for future research.

5.1 Summary of results

5.1.1 Farm characteristics

The size of the household, the gender and age of the head of the household, and the level of education of the household head are some of the very important characteristics of the farm. The results of this study reveal that a household in Kigali rural province has on average 5 people; male-headed households have decreased about 30%, from 93% in 1981 to 63% in 2001; and the proportion of illiterate household heads

exceeds 50%, the proportion of female illiterate households being relatively high compared to that of male household heads. The proportions of elderly household heads did not change a lot but diverges by gender: in 2001, the majority of elderly household heads were female whereas in 1981 most of the elderly household heads were male. The Plateau central agro-ecological zone has the highest proportion of both female-headed households and of elderly-headed households.

Kigali rural province has limited natural resources, including a shortage of land due mostly to hilly and mountainous terrain and costly-to-use wetlands. The average farm size in Kigali rural province (1.22 hectares) is higher than the average at the national level (0.86 hectares) with some variation by agro-ecological zone. The largest average farm size appears in Plateau central, the smallest in Bugesera. The land distribution patterns indicate that land is somewhat concentrated in the upper quartile households. On a per farm basis, the fourth quartile (large landowners) holds some 54 percent of land in Kigali rural province. A very similar pattern persists even when the size of the household is expressed in terms of adult equivalents. At the lowest quartile of households the farmland size is very small, on average about one-third of a hectare. The first quartile households in Kigali rural province hold less than 10% of land both in terms of land area farmed by a household and land area farmed by an adult equivalent. The Plateau central agro-ecological zone has both the highest average area per household (1.58 hectares) and average area per adult equivalent (0.35 hectare).

Results in this study show that the pattern of land use does not vary by farm size in Kigali rural province. The proportion of land allocated to different categories of crops lies in the same range for small and large farmers with some exceptions. A large

proportion of land is allocated to legumes, mostly beans and roots and tubers, reflecting the food habits in Rwanda in general and in the Kigali rural province in particular.

Six crops appear to be the most important farm activities in Kigali rural province. Beans, sweet potato and cassava are the major staple foods whereas banana, sorghum and peanuts are grown as cash crops. Beans and sorghum are ranked in the top three crops in the three agro-ecological zones suggesting that the two crops are perceived by farmers in Kigali rural province as important crops.

Cassava and sweet potato constitute the major source of calories in Kigali rural province, contributing more than 50% of total household food energy. Beans constitute the third contributor to the household food energy just before sorghum and maize in Plateau de l'Est and Bugesera, and before sorghum in Plateau central agro-ecological zone. Results in this study reveal that household crop production in the Plateau de l'Est and Bugesera/Mayaga cover all the needs of the household whereas a household in the Plateau central zone has to buy some food on the market to complement its own production.

5.1.2 Crop budget analysis

5.1.2.1 Plateau de l'Est zone

The remuneration rate is negative for all the three combinations of beans/modules (traditional modes of production, climbing beans production with NPK and climbing beans production with DAP) and sorghum grown with NPK and, almost zero for soybeans with traditional modes of production. It is positive for all other combinations that is, soybean and sorghum grown with DAP, sorghum without fertilizer and, maize

without and with fertilizer use. Since agriculture in Rwanda is more labor and land intensive rather than capital intensive, criteria such as interest rate of bank savings or opportunity cost of capital has less meaning to determine the desirable level of remuneration rate. In this context, a positive remuneration rate indicates that the production process of interest is good. Compared to the traditional modes of production, the use of fertilizer improves the remuneration rate only for soybean and sorghum, in the plateau de l'Est agro-ecological zone.

Of the four crops selected in plateau de l'Est zone, the use of fertilizer would generate returns to family labor equal to or greater than the local agricultural labor wage for three of them, that is, maize, soybeans and sorghum. Even though all of these three crops have positive margins at all the three margin levels, the difference between with and without fertilizer margins seems to be significant only for soybeans and sorghum. The comparison of the two types of fertilizer shows that the DAP is superior to NPK for all crops.

In sum, soybeans, sorghum and maize provide the best returns to the combination of organic and mineral fertilizer in the Kigali Est zone but production intensification by fertilizer use would be financially more attractive for soybeans and sorghum production.

5.1.2.2 Plateau central zone

In this zone, results on the three crop budget analysis criteria have some similarities but also some differences with those in the plateau de l'Est agro-ecological zone. Three combinations, that is, sorghum, soybeans and maize grown with DAP, have a positive net benefit; all other combinations have negative benefit. For the three crops with

positive net benefit, two of them, sorghum and soybeans, have margins that are positive at all three levels of margin, implying that the use of DAP on these crops generates enough revenue to cover all costs, monetary and non-monetary, engaged in the production process.

The returns to family labor are greater than the agricultural labor wage for sorghum production with the combination "DAP + urea" as mineral fertilizer, and almost equal to the labor wage for soybeans with fertilizer DAP. For all other combinations, returns to family labor are not only less than the labor wage but also less than the minimum rate assumed acceptable by farmers when working on their own land.

In sum, sorghum and soybeans would give the best returns to the combination of organic and mineral fertilizer in the Kigali central zone and their intensification by fertilizer use would be financially attractive.

5.1.2.3 Bugesera zone

Sorghum is the only crop perceived by previous studies (Kelly and Murekezi, 2000) as potentially profitable with fertilizer use in Bugesera zone. The remuneration rate, the returns to family labor and the margins generated with the available data do not support that assumption for NPK but they do for the combination DAP + urea. For all of these three criteria, the traditional modes of production are superior to the use of NPK, due partially to the higher cost share (34.5%) of that chemical fertilizer. In contrast, the use of the combination "DAP + urea" improves all three crop budget analysis criteria, compared to the traditional modes of production.

In sum, improved agricultural techniques would be more profitable than the traditional modes of production, when based on the use of "DAP + Urea" as fertilizer.

5.2 Policy implications

Previous studies on fertilizer profitability in Rwanda had used the v/c ratio approach. The full budget analysis approach used in this study to assess the profitability of fertilizer use in Kigali rural province has the advantages of considering the whole crop production process and incorporating the full range of costs when calculating the profits that can be obtained by farmers. Indeed, it is easy for an extension agent to convince a farmer to adopt new technology by showing him a more complete estimate of his potential profit rather than the estimated profit drawn from v/c ratio approach.

The intensification of agriculture in Rwanda in general and in Kigali rural province through improved agricultural inputs (fertilizer, seeds, pesticides, etc.) constitutes an obvious way of solving the complex agricultural problem in the context of land scarcity. The solution is not that simple, however. There is a real need for a multi-sectoral remedy.

Findings reviewed in the previous section call not only for more agricultural research but also for socio-economic research. Agricultural research must develop technologies (more productive varieties and improved practices) which are so profitable that farmers do not hesitate to switch to them. Socio-economic research (e.g., capacity constraints studies, adoption of improved technologies studies) is needed first, to help agronomists to produce technologies that meet the real needs of farmers and to promote current minor but more profitable crops such as soybeans and second, to improve fertilizer use efficiency.

5.3 Limitations and suggestions for further research

The data used in this study as said in the previous chapter came from typical budgets prepared by agricultural specialists of the Ministry of Agriculture, using cost prices prepared by the improved seeds government agency (Projet de Semences Selectionées) and information from farm surveys and an agricultural market prices project (PASAR). The major limitations related to these data are:

- Labor data for different agricultural operations are national-level averages;
- Yields for research recommendations are broken down for three broad categories of land quality, that is, high, medium and low fertility;
- The individual effect of chemical fertilizer cannot be differentiated from that of organic fertilizer.

Further research on the profitability of crops based on data from on-farm trials designed to distinguish the separate effects of chemical and organic fertilizer for all agro-ecological zones would not only produce more accurate estimates of crop profits through crop budgets but also, through partial budgets, indicate which technological packages are agronomically different and economically superior to other alternatives, and socially acceptable to farmers.

Improved agricultural technologies can meet the above objectives and still be unused by farmers. Well-designed studies on farmers' capacity to invest in technologies that are economically attractive would be good complements to the profitability studies by providing recommendations on realistic solutions to capacity constraints faced by farmers.

APPENDIX A
DATA FOR CROP BUDGETS ELABORATION

Table A-1: Average yields (kg/ha) in the three major agro-ecological zones of Kigali rural, Rwanda , 2001

	Agro-ecological zones								
	Plateau de l'Est			Plateau central			Bugesera		
	Mod. 1*	Mod. 2a**	Mod. 2b	Mod. 1	Mod.2a	Mod.2b	Mod. 1	Mod. 2a	Mod. 2b
Beans	740	1650	1020	500	1650	865	-	-	-
Sorghum	1050	2000	807	620	2000	1977	1100	2000	1864
Soybeans	640	-	1400	300	-	1108	-	-	-
Maize	1300	2300	-	800	1400	1547	-	-	-

Source: MINAGRI/FSRP survey data (for module 1), MINAGRI 1997 and Kelly and Murekezi, 2000 (for module 2).

* Traditional modes of production.
**Improved agricultural techniques (2a = NPK, 2b = DAP).

Table A-2: Average prices (Frw) in the three major agro-ecological zones of Kigali rural, Rwanda , 2001

	Agro-ecological zones		
	Plateau de l'Est	Plateau central	Bugesera
Beans	95	100	-
Sorghum	80	88	86
Soybeans	131	141	-
Maize	93	92	-
Mineral fertilizer(NPK)	223	233	222
Mineral fertilizer(DAP)	203	213	200
Mineral fertilizer(Urea)	225	239	219

Source: MINAGRI/PASAR[10]

[10] PASAR is a market information project

Table A-3: Standards of person-days per hectare for crops perceived as profitable with fertilizer use in Kigali rural province

	Maize	Sorghum	Climbing beans	Soybeans
Clearing	-	-	10	10
First plow	66	66	66	66
Second plow	50	50	50	50
Leveling	10	10	10	10
Seeding	12	12	17	20
Weeding	33	33	66	66
Mounding	20	20	-	-
Pesticide appl.	8	8	25	8
Fertilizer	10	10	10	10
Selection	2	2	4	4
Sticking	-	-	50	-
Harvesting	25	20	20	20
Threshing	60	-	-	-
Winnowing	15	13	5	4
Drying	5	5	3	3
Sorting	-	-	1.5	1
Storage	6	5	3	2
Others	*130*	*130*	*130*	*130*

Source: MINAGRI, 1997

APPENDIX B

CROP BUDGETS, MARGINS, COST SHARES, RETURNS TO HOUSEHOLD LABOR AND REMUNERATION RATE

Table B-1. Beans[(a)] budget for plateau de l'est agricultural zone, Module 1, Kigali rural province, Rwanda. (per hectare)

ITEMS	UNIT	QUANTITY	UNIT PRICE	MONETARY VALUE (Frw)
PRODUCTION				
-Legume	Kg	740	95	70300
(1)Gross revenue				70300
Monetary variable input costs				
Seeds	Kg	60	100	6000
Hired labor	M.D	28	300	8400
(2) Total M.V.I.C				14400
Non-monet. variable input costs				
Organic fertilizer	Kg	3,750	2	7500
Household labor	M.D	248	240	59520
Capital cost	-	-	-	1440
(3) Total N.V.I.C				68460
Fixed costs				
Small agr. equipment	-	-	-	1,317
(4) Total F.C				1,317
(5)Total variable input cost (2+3)				82860
(6)Total costs (2 + 3 + 4)				84,177
(7)Gross Margin[Monetary] (1- 2)				55900
(8)Total Gross Margin (1 – 5)				-12560
(9)Net Margin (1– 6)				-13,877
Returns to family labor per day[(b)]				184
Remuneration rate (8/5 * 100)				-15%

(a) The data used do not differentiate the two bean categories, climbing and dwarf bean; most farmers grow the second category which does not need sticks.

(b) Returns to family labor per day = (Net Margin + Monetary value of household labor)/ Quantity of household labor.

Table B-2. Climbing beans budget for plateau de l'est agricultural zone, Improved techniques, Kigali rural province, Rwanda. (per hectare)

ITEMS	UNIT	QUANTITY	UNIT PRICE	Module 2a (Frw)	Module 2b (Frw)
PRODUCTION					
-Legume	Kg	1,460	95	138700	
	Kg	1556	95		147820
(1)Gross revenue				138700	147820
Monetary variable input costs					
Seeds	Kg	60	235	14100	14100
Mineral fertilizer (NPK)	Kg	200	223	44600	
Mineral fertilizer (DAP)	Kg	100	203		20300
Organic fertilizer	Kg	7750	2	15500	
Hired labor (module 2a)	M.D	37	300	11100	
Hired labor (Module 2b)	M.D	36	300		10800
Sticks		22500	8	30000	30000
(2) Total M.V.I.C				115300	75200
Non-monet. variable input costs					
Organic fertilizer	Kg	3750	2	7500	7500
Household labor (module 2a)	M.D	334	240	80160	
Household labor (module 2b)	M.D	327	240		78480
Capital cost	-	-	-	11530	7520
(3) Total N.V.I.C				99190	93500
Fixed costs					
Small agr. equipment	-	-	-	1317	1317
(4) Total F.C				1317	1317
(5)Total variable input cost (2+3)				214490	168700
(6)Total costs (2 + 3 + 4)				215807	170017
(7)Gross Margin[Monetary] (1- 2)				23400	72620
(8) Total Gross Margin (1 – 5)				-75790	-20880
(9)Net Margin (1– 6)				-77107	-22197
Returns to family labor per day[(b)]				9	172
Remuneration rate (8/5 * 100)				-35	-12%
V/C ratio[(c)]				1.14	3.8

(a) Sticks are used for three years and for two seasons per year; hence the total charge has to be divided by six.

(b) Returns to family labor per = (Net Margin + Monetary value of household labor)/ Quantity of household labor.

(c) v/c ratio = (Gross revenue module 2 - Gross revenue module 1)/ (Total mineral and organic fertilizer module 2 – Organic fertilizer module 1)

Table B-3. Sorghum budget for plateau de l'est agricultural zone, Module 1, Kigali rural province, Rwanda. (per hectare)

ITEMS	UNIT	QUANTITY	UNIT PRICE	MONETARY VALUE (Frw)
PRODUCTION				
-Grain	Kg	1,050	80	84000
(1)Gross revenue				84000
Monetary variable input costs				
Hired labor	M.D	23	300	6900
(2) Total M.V.I.C				6900
Non-monet. variable input costs				
Seeds	Kg	30	80	2400
Organic fertilizer	Kg	3750	2	7500
Household labor	MD	206	240	49440
Capital cost	-	-	-	690
(3) Total N.V.I.C				60030
Fixed costs				
Small agr. equipment	-	-	-	1317
(4) Total F.C				1317
(5)Total variable input cost (2+3)				66930
(6)Total costs (2 + 3 + 4)				68247
(7)Gross Margin[Monetary] (1- 2)				77100
(8) Total Gross Margin (1 – 5)				17070
(9)Net Margin (1– 6)				15753
Returns to family labor per day[(a)]				316
Remuneration rate (8/5 * 100)				26%

(a) Returns to family labor per day = (Net Margin + Monetary value of household labor)/ Quantity of household labor.

Table B-4. Sorghum budget for plateau de l'est agricultural zone, Modules 2, Kigali rural province, Rwanda (per hectare).

ITEMS	UNIT	QUANTITY	UNIT PRICE	Module 2a (Frw)	Module 2b (Frw)
PRODUCTION					
-Grain	Kg	1,810	80	144800	
	Kg	1696	80		135680
(1)Gross revenue				144800	135680
Monetary variable input costs					
Mineral fertilizer (NPK)	Kg	250	223	55750	
Mineral fertilizer (DAP)	Kg	76	203		15428
Mineral fertilizer (Urea)	Kg	78	225		17550
Organic fertilizer	Kg	7,750	2	15500	
Hired labor (Module 2a)	M.D	25	300	7500	
Seeds	Kg	30	80	2400	2400
Hired labor (Module 2b)	M.D	24	300		7200
Pesticide (Dursiban)	Kg	20	250	5000	5000
(2) Total M.V.I.C				86150	47578
Non-monet. variable input costs					
Organic fertilizer	Kg	3,750	2	7500	7500
Household labor (module 2a)	M.D	222	240	53280	
Household labor (module 2b)	M.D	219	240		52560
Capital cost				8615	4758
(3) Total N.V.I.C				69395	64818
Fixed costs					
Small agr. equipment	-	-	-	5033	5033
(4) Total F.C				5033	5033
(5)Total variable input cost (2+3)				155545	112396
(6)Total costs (2 + 3 + 4)				160578	117429
(7)Gross Margin[Monetary] (1- 2)				58650	88102
(8)Total Gross Margin (1 – 5)				-10745	23284
(9)Net Margin (1– 6)				-15778	18251
Returns to family labor per day[(a)]				169	323
Remuneration rate (8/5 * 100)				-6.9%	21%
V/C ratio[(b)]				0.85	1.6

(a) Returns to family labor per day= (Net Margin + Monetary value of household labor)/ Quantity of household labor.

(b) v/c ratio = (Gross revenue module 2 - Gross revenue module 1)/ (Total mineral and organic fertilizer module 2 – Organic fertilizer module 1)

Table B-5. Soybeans budget for plateau de l'est agricultural zone, Traditional module, Kigali rural province, Rwanda (per hectare).

ITEMS	UNIT	QUANTITY	UNIT PRICE	MONETARY VALUE (Frw)
PRODUCTION				
-Legume	Kg	640	131	83840
(1)Gross revenue				83840
Monetary variable input costs				
Seeds	Kg	70	131	9170
Hired labor	M.D	27	300	8100
(2) Total M.V.I.C				17270
Non-monet. variable input costs				
Organic fertilizer	Kg	3,000	2	6000
Household labor	M.D	245	240	58800
Capital cost				1727
(3) Total N.V.I.C				66527
Fixed costs				
Small agr. equipment	-	-	-	1,317
(4) Total F.C				1,317
(5)Total variable input cost (2+3)				83797
(6)Total costs (2 + 3 + 4)				85114
(7)Gross Margin[Monetary] (1-2)				66570
(8) Total Gross Margin (1 – 5)				43
(9)Net Margin (1– 6)				-1274
Returns to family labor per day[(a)]				235
Remuneration rate (8/5 * 100)				0.05%

(a) Returns to family labor per day = (Net Margin + Monetary value of household labor)/ Quantity of household labor.

Table B-6. Soybeans budget for plateau de l'est agricultural zone, Module 2, Kigali rural province, Rwanda (per hectare).

ITEMS	UNIT	QUANTITY	UNIT PRICE	MONETARY VALUE (Frw)
PRODUCTION				
-Legume	Kg	1,248	131	163488
(1)Gross revenue				163488
Monetary variable input costs				
Seeds	Kg	70	156	10920
Mineral fertilizer (DAP)	Kg	100	203	20300
Organic fertilizer	Kg	7000	2	14000
Hired labor	M.D	29	300	8700
(2) Total M.V.I.C				53920
Non-monet. variable input costs				
Organic fertilizer	Kg	3,000	2	6000
Household labor	M.D	261	240	62640
Capital cost				5392
(3) Total N.V.I.C				74032
Fixed costs				
Small agr. equipment	-			1317
(4) Total F.C				1317
(5)Total variable input cost (2+3)				127952
(6)Total costs (2 + 3 + 4)				129269
(7)Gross Margin[Monetary] (1- 2)				109568
(8)Total Gross Margin (1 – 5)				35536
(9)Net Margin (1– 6)				34219
Returns to family labor per day[(a)]				371
Remuneration rate (8/5 * 100)				28%
V/C ratio[(b)]				2.3

(a) Returns to family labor per day = (Net Margin + Monetary value of household labor)/ Quantity of household labor.

(b) v/c ratio = (Gross revenue module 2 - Gross revenue module 1)/ (Total mineral and organic fertilizer module 2 – Organic fertilizer module 1)

Table B-7. Maize budget for plateau de l'est agricultural zone, Traditional module, Kigali rural province, Rwanda. (per hectare)

ITEMS	UNIT	QUANTITY	UNIT PRICE	MONETARY VALUE (Frw)
PRODUCTION				
-Legume	Kg	1,080	93	100440
(1)Gross revenue				100440
Monetary variable input costs				
Hired labor	M.D	22	300	6600
(2) Total M.V.I.C				6600
Non-monet. variable input costs				
Seeds	Kg	40	93	3720
Organic fertilizer	Kg	3,000	2	6000
Household labor	M.D	199	240	47760
Capital cost				660
(3) Total N.V.I.C				58140
Fixed costs				
Small agr. equipment	-			1317
(4) Total F.C				1317
(5)Total variable input cost (2+3)				64740
(6)Total costs (2 + 3 + 4)				66057
(7)Gross Margin[Monetary] (1- 2)				93840
(8)Total Gross Margin (1 – 5)				35700
(9)Net Margin (1– 6)				34383
Returns to family labor per day[(a)]				413
Remuneration rate (8/5 * 100)				55%

(a) Returns to family labor per day = (Net Margin + Monetary value of household labor)/Quantity of household

Table B-8. Maize budget for plateau de l'est agricultural zone, Module 2, Kigali rural province, Rwanda. (per hectare)

ITEMS	UNIT	QUANTITY	UNIT PRICE	MONETARY VALUE (Frw)
PRODUCTION				
-Grain	Kg	2,056	93	191208
(1)Gross revenue				191208
Monetary variable input costs				
Mineral fertilizer (NPK)	Kg	250	223	55750
Organic fertilizer	Kg	7,000	2	14000
Hired labor	M.D	24	300	7200
Seeds	Kg	40	93	3720
(2) Total M.V.I.C				80670
Non-monet. variable input costs				
Organic fertilizer	Kg	3,000	2	6000
Household labor	M.D	211	240	50640
Capital cost	-	-	-	8067
(3) Total N.V.I.C				64707
Fixed costs				
Small agr. equipment	-			1317
(4) Total F.C				1317
(5)Total variable input cost (2+3)				145377
(6)Total costs (2 + 3 + 4)				146694
(7)Gross Margin [Monetary](1- 2)				110538
(8)Total Gross Margin (1 – 5)				45831
(9)Net Margin (1– 6)				44514
Returns to family labor per day[(a)]				451
Remuneration rate (8/5 * 100)				32%
V/C ratio[(b)]				1.3

(a) Returns to family labor per day = (Net Margin + Monetary value of household labor)/ Quantity of household labor.

(b) v/c ratio = (Gross revenue module 2 - Gross revenue module 1)/ (Total mineral and organic fertilizer module 2 – Organic fertilizer module 1)

Table B-9: Margins in Plateau de l'Est agro-ecological zone, Kigali rural province, Rwanda, 2001.

	Beans	Sorghum	Soybeans	Maize
GM1	55,900	77,100	66,570	93,840
TGM1	-12,560	17,070	43	35,700
NM1	-13,877	15,753	-1,274	34,383
GM2a	23,400	58,650	-	110,538
TGM2a	-75,790	-10,745	-	45,831
NM2a	-77,107	-15,778	-	44,514
GM2b	72,620	88,102	109,568	-
TGM2b	-20,880	23,284	35,536	-
NM2b	-22,197	18,251	34,219	-

Source: Grouped from crop budgets in tables B-1 to B-8

Notes:
GM1= Gross margin for Traditional module
TGM1= Total gross margin for traditional module
NM1= Net margin for traditional module
GM2= Gross margin for Improved techniques
TGM2= Total gross margin for improved techniques
NM2= Net margin for improved techniques

Table B-10: Cost shares in plateau de l'Est agro-ecological zone, Kigali rural province, Rwanda, 2001 (percentage).

	C.Beans M1*	C.Beans M2a**	C.Beans M2b**	Sorghum M1	Sorghum M2a	Sorghum M2b	Soybeans M1	Soybeans M2	Maize M1	Maize M2
Mineral fertilizer	0	21.9	12.7	0	34.7	29.1	0	17.4	0	38.7
Organic fertilizer	8.2	11.3	4.7	14.1	14.4	6.6	7	15.6	9.1	13.9
Hired labor	10.0	5.3	6.7	9.7	4.6	6.5	9.6	6.7	10	4.7
Sticks	0	14.7	18.7	0	0	0	0	0	0	0
Small agr. equipments	1.4	0.6	0.8	1.9	3.1	4.4	1.5	1	2	0.9
Pesticide	0	0	0	0	3.1	4.4	0	0	0	0
Seeds	6.2	2.8	3.6	3.4	1.5	2.1	10.8	7.2	5.6	2.6
Household labor	72.3	38.2	48.6	69.8	33.2	47.1	68.9	47.9	86.8	33.8
Capital cost	1.8	5.3	4.3	1.2	5.2	4.0	2.2	4.3	1.2	5.4

Source: Grouped from crop budgets in tables B-1 to B-8

* Traditional modes of production.
**Improved agricultural techniques

Table B-11. Beans[a] budget for "Plateau central agricultural zone", traditional module, Kigali rural province, Rwanda. (per hectare)

ITEMS	UNIT	QUANTITY	UNIT PRICE	MONETARY VALUE (Frw)
PRODUCTION				
-Legume	Kg	500	100	50000
(1)Gross revenue				50000
Monetary variable input costs				
Seeds	Kg	60	100	6000
Hired labor	M.D	28	300	8400
(2) Total M.V.I.C				14400
Non-monet. variable input costs				
Organic fertilizer	Kg	3,750	2	7500
Household labor	M.D	248	240	59520
Capital cost	-	-	-	1440
(3) Total N.V.I.C				68460
Fixed costs				
Small agr. equipments	-	-	-	1317
(4) Total F.C				1317
(5)Total variable input cost (2+3)				82860
(6)Total costs (2 + 3 + 4)				84177
(7)Gross Margin[Monetary] (1- 2)				35600
(8)Total Gross Margin (1 – 5)				-32860
(9)Net Margin (1– 6)				-34177
Returns to family labor[b]				102
Remuneration rate (8/5 * 100)				-40%

(a) The data used do not differentiate the two bean categories, climbing and dwarf bean; most of farmers grow the second category that does not need sticks.

(b) Returns to family labor = (Net Margin + Monetary value of household labor)/ Quantity of household labor.

Table B-12. Climbing beans budget for "Plateau central agricultural zone", improved techniques, Kigali rural province, Rwanda. (per hectare)

ITEMS	UNIT	QUANTITY	UNIT PRICE	Module 2a (Frw)	Module 2b (Frw)
PRODUCTION					
-Legume	Kg	980	100	98000	
	Kg	792	100		79200
(1)Gross revenue				98000	79200
Monetary variable input costs					
Seeds	Kg	60	235	14100	14100
Mineral fertilizer (NPK)	Kg	200	223	44600	
Mineral fertilizer (DAP)	Kg	100	213		21300
Organic fertilizer	Kg	7,750	2	15500	
Hired labor (NPK)	M.D	37	300	11100	
Hired labor (DAP)	M.D	36	300		10800
Sticks		22,500	8	30000	30000
(2) Total M.V.I.C				115300	76200
Non-monet. variable input costs					
Organic fertilizer	Kg	3,750	2	7500	7500
Household labor (NPK)	M.D	334	240	80160	
Household labor (DAP)	M.D	327	240		78480
Capital cost	-	-	-	11530	7620
(3) Total N.V.I.C				99190	93600
Fixed costs					
Small agr. equipment	-	-	-	1317	1317
(4) Total F.C				1317	1317
(5)Total variable input cost (2+3)				214490	169800
(6)Total costs (2 + 3 + 4)				215807	171117
(7)Gross Margin[Monetary] (1- 2)				-17300	3000
(8)Total Gross Margin (1 – 5)				-116490	-90600
(9)Net Margin (1– 6)				-117807	-91917
Returns to family labor per day[(b)]				-113	-41
Remuneration rate (8/5 * 100)				-54%	-53%
V/C ratio[(c)]				0.8	1.4

(a) Sticks are used for three years and then for six seasons, hence the total charge has to be divided by six.

(b) Returns to family labor per day = (Net Margin + Monetary value of household labor)/ Quantity of household labor.

(c) v/c ratio = (Gross revenue module 2 - Gross revenue module 1)/ (Total mineral and organic fertilizer module 2 – Organic fertilizer module 1)

Table B-13: Sorghum budget for plateau de central agricultural zone, traditional module, Kigali rural province, Rwanda (per hectare).

ITEMS	UNIT	QUANTITY	UNIT PRICE	MONETARY VALUE (Frw)
PRODUCTION				
-Grain	Kg	620	88	54560
(1)Gross revenue				54560
Monetary variable input costs				
Hired labor	M.D	23	300	6900
(2) Total M.V.I.C				6900
Non-monet. variable input costs				
Seeds	Kg	30	88	2640
Organic fertilizer	Kg	5000	2	10000
Household labor	M.D	206	240	49440
Capital cost	-	-	-	690
(3) Total N.V.I.C				62770
Fixed costs				
Small agr. equipment	-	-	-	1317
(4) Total F.C				1317
(5)Total variable input cost (2+3)				69670
(6)Total costs (2 + 3 + 4)				70987
(7)Gross Margin[Monetary] (1- 2)				47660
(8)Total Gross Margin (1 – 5)				-15110
(9)Net Margin (1– 6)				-16427
Returns to family labor per day[(a)]				160
Remuneration rate (8/5 * 100)				-22%

(a) Returns to family labor per day = (Net Margin + Monetary value of household labor)/ Quantity of household labor.

Table B-14. Sorghum budget for plateau central agricultural zone, improved techniques, Kigali rural province, Rwanda(per hectare).

ITEMS	UNIT	QUANTITY	UNIT PRICE	Module 2a (Frw)	Module 2b (Frw)
PRODUCTION					
-Grain	Kg	1084	88	95392	
	Kg	1,706	88		150128
(1)Gross revenue				95392	150128
Monetary variable input costs					
Mineral fertilizer (NPK)	Kg	250	233	58250	
Mineral fertilizer (DAP)	Kg	90	213		19170
Mineral fertilizer (Urea)	Kg	70	239		16730
Organic fertilizer	Kg	7,750	2	15500	
Hired labor (Module 2a)	M.D	25	300	7500	
Hired labor (Module 2b)	M.D	24	300		7200
Pesticide (Dursiban)	Kg	20	250	5000	5000
Seeds	Kg	30	88	2640	2640
(2) Total M.V.I.C				88890	50740
Non-monet. variable input costs					
Organic fertilizer	Kg	3,750	2	7500	7500
Household labor (module 2a)	M.D	222	240	53280	
Household labor (module 2b)	M.D	219	240		52560
Capital cost	-	-	-	8889	5074
(3) Total N.V.I.C				69669	65134
Fixed costs					
Small agr. equipments	-	-	-	5033	5033
(4) Total F.C				5033	5033
(5)Total variable input cost (2+3)				158559	115874
(6)Total costs (2 + 3 + 4)				163592	120907
(7)Gross Margin[Monetary](1- 2)				6502	99388
(8)Total Gross Margin (1 – 5)				-63167	34254
(9)Net Margin (1– 6)				-68200	29221
Returns to family labor per day[(a)]				-67	373
Remuneration rate (8/5 * 100)				-40%	30%
V/C ratio[(b)]				0.6	2.86

(a) Returns to family labor per day = (Net Margin + Monetary value of household labor)/ Quantity of household labor.

(b) v/c ratio = (Gross revenue module 2 - Gross revenue module 1)/ (Total mineral and organic fertilizer module 2 – Organic fertilizer module 1)

Table B-15. Soybeans budget for plateau central agricultural zone, traditional module, Kigali rural province, Rwanda (per hectare).

ITEMS	UNIT	QUANTITY	UNIT PRICE	MONETARY VALUE (Frw)
PRODUCTION				
-Legume	Kg	300	141	42300
(1)Gross revenue				42300
Monetary variable input costs				
Seeds	Kg	70	141	9870
Hired labor	M.D	27	300	8100
(2) Total M.V.I.C				17970
Non-monet. variable input costs				
Organic fertilizer	Kg	3,000	2	6000
Household labor	M.D	245	240	58800
Capital cost	-			1797
(3) Total N.V.I.C				66597
Fixed costs				
Small agr. equipment	-	-	-	1317
(4) Total F.C				1317
(5)Total variable input cost (2+3)				84567
(6)Total costs (2 + 3 + 4)				85884
(7)Gross Margin[Monetary] (1- 2)				24330
(8)Total Gross Margin (1 – 5)				-42267
(9)Net Margin (1– 6)				-43584
Returns to family labor per day[(a)]				62
Remuneration rate (8/5 * 100)				-50%

(a) Returns to family labor per day = (Net Margin + Monetary value of household labor)/ Quantity of household labor.

Table B-16. Soybeans budget for plateau central agricultural zone, improved techniques, Kigali rural province, Rwanda (per hectare).

ITEMS	UNIT	QUANTITY	UNIT PRICE	MONETARY VALUE (Frw)
PRODUCTION				
-Legume	Kg	886	141	124926
(1)Gross revenue				124926
Monetary variable input costs				
Seeds	Kg	70	156	10920
Mineral fertilizer (DAP)	Kg	80	213	17040
Mineral fertilizer (Urea)	Kg	10	239	2390
Hired labor	M.D	29	300	8700
(2) Total M.V.I.C				39050
Non-monet. variable input costs				
Organic fertilizer	Kg	3,000	2	6000
Household labor	M.D	261	240	62640
Capital cost	-	-	-	3905
(3) Total N.V.I.C				72545
Fixed costs				
Small agr. equipments	-	-	-	1317
(4) Total F.C				1317
(5)Total variable input cost (2+3)				111595
(6)Total costs (2 + 3 + 4)				112912
(7)Gross Margin[Monetary] (1- 2)				85876
(8)Total Gross Margin (1 – 5)				13331
(9)Net Margin (1– 6)				12014
Returns to family labor per day[(a)]				286
Remuneration rate (8/5 * 100)				12%
V/C ratio[(b)]				4.3

(a) Returns to family labor per day = (Net Margin + Monetary value of household labor)/ Quantity of household labor.

(b) v/c ratio = (Gross revenue module 2 - Gross revenue module 1)/ (Total mineral and organic fertilizer module 2 – Organic fertilizer module 1)

Table B-17. Maize budget for plateau central agricultural zone, traditional module, Kigali rural province, Rwanda (per hectare).

ITEMS	UNIT	QUANTITY	UNIT PRICE	MONETARY VALUE (Frw)
PRODUCTION				
- Grain	kg	625	92	57500
(1)Gross revenue				57500
Monetary variable input costs				
Hired labor	M.D	22	300	6600
(2) Total M.V.I.C				6600
Non-monet. variable input costs				
Seeds	Kg	40	92	3680
Organic fertilizer	Kg	3,000	2	6000
Household labor	M.D	199	240	47760
Capital cost	-			660
(3) Total N.V.I.C				58100
Fixed costs				
Small agr. equipment	-			1317
(4) Total F.C				1317
(5)Total variable input cost (2+3)				64700
(6)Total costs (2 + 3 + 4)				66017
(7)Gross Margin[Monetary] (1- 2)				50900
(8)Total Gross Margin (1 – 5)				-7200
(9)Net Margin (1– 6)				-8517
Returns to family labor per day[(a)]				197
Remuneration rate (8/5 * 100)				-11%

(a) Returns to family labor per day = (Net Margin + Monetary value of household labor)/ Quantity of household labor.

Table B-18. Maize budget for "Plateau central agricultural zone", improved techniques, Kigali rural province, Rwanda (per hectare).

ITEMS	UNIT	QUANTITY	UNIT PRICE	Module 2a (Frw)	Module 2b (frw)
PRODUCTION					
-Grain	Kg	1245	92	114540	
	Kg	1223	92		112516
(1)Gross revenue				114540	112516
Monetary variable input costs					
Mineral fertilizer (NPK)	Kg	250	233	58250	
Mineral fertilizer (DAP)	Kg	90	213		19170
Mineral fertilizer (urea)	Kg	110	239		26290
Organic fertilizer	Kg	7,000	2	14000	
Hired labor (module 2a)	M.D	24	300	7200	
Hired labor (module 2b)	M.D	23	300		6900
Seeds	Kg	40	92	3680	3680
(2) Total M.V.I.C				83130	56040
Non-monet. variable input costs					
Organic fertilizer	Kg	3,000	2	6000	6000
Household labor (module 2a)	M.D	211	240	50640	
Household labor	M.D	210	240		50400
Capital cost	-			8313	5604
(3) Total N.V.I.C				64953	62004
Fixed costs					
Small agr. equipment	-			1317	1317
(4) Total F.C				1317	1317
(5)Total variable input cost (2+3)				148083	118044
(6)Total costs (2 + 3 + 4)				149400	119361
(7)Gross Margin[Monetary] (1- 2)				31410	56476
(8)Total Gross Margin (1 – 5)				-33543	-5528
(9)Net Margin (1– 6)				-34860	-6845
Returns to family labor per day[(a)]				75	214
Remuneration rate (8/5 * 100)				-23%	-5%
V/C ratio[(b)]				0.8	1.2

(a) Returns to family labor per day= (Net Margin + Monetary value of household labor)/ Quantity of household labor.

(b) v/c ratio = (Gross revenue module 2 - Gross revenue module 1)/ (Total mineral and organic fertilizer module 2 – Organic fertilizer module 1)

Table B-19: Margins in Plateau central agro-ecological zone, Kigali rural province, Rwanda, 2001.

	Beans	Sorghum	Soybeans	Maize
GM1	35,600	47660	24330	50,900
TGM1	-32,860	-15110	-42267	-7,200
NM1	-34,177	-16427	-43584	-8,517
GM2a	-17,300	6,502	-	31,410
TGM2a	-116,490	-63,167	-	-33,543
NM2a	-117,807	-68,200	-	-34,860
GM2b	3,000	99,388	85,876	56,476
TGM2b	-90,600	34,254	13,331	-5,528
NM2b	-91,917	29,221	12,014	-6,845

Source: Grouped from crop budgets in tables B-11 to B-18

Notes:
GM1= Gross margin for Traditional module
TGM1= Total gross margin for traditional module
NM1= Net margin for traditional module
GM2= Gross margin for Improved techniques
TGM2= Total gross margin for improved techniques
NM2= Net margin for improved techniques

Table B-20: Cost shares in plateau central agro-ecological zone, Kigali rural province, Rwanda, 2001 (percentage).

	C.Beans M1*	C.Beans M2**	Sorghum M1	Sorghum M2	Soybeans M1	Soybeans M2a	Soybeans M2b	Maize M1	Maize M2
Mineral fertilizer	0	21.8	0	35.6	0	17.9	17.6	0	39.7
Organic fertilizer	8.2	11.3	14.1	14.1	7	15.4	5.4	9.1	13.6
Hired labor	10.0	5.3	9.7	4.5	9.5	6.6	7.7	10	4.6
Sticks	0	14.7	0	0	0	0	0	0	0
Small agr. equipments	1.4	0.6	1.9	3.1	1.5	1	1.2	2	0.9
Pesticide	0	0	0	3.1	0	0	0	0	0
Seeds	6.5	2.9	3.7	1.6	11.5	7.6	8.9	5.6	2.5
Household labor	72.1	38.1	69.6	32.6	68.3	47.2	55.6	72.2	33.1
Capital cost	1.8	5.3	1.2	5.6	2.3	4.4	3.5	1.2	5.5

Source: computed from crop budgets in tables B-11 to B-18

* Traditional modes of production.

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Table B-21. Sorghum budget for Bugesera agricultural zone, traditional module, Kigali rural province, Rwanda (per hectare).

ITEMS	UNIT	QUANTITY	UNIT PRICE	MONETARY VALUE (Frw)
PRODUCTION				
-Grain	Kg	1,100	86	94600
(1)Gross revenue				94600
Monetary variable input costs				
Hired labor	M.D	23	300	6900
(2) Total M.V.I.C				6900
Non-monet. variable input costs				
Seeds	Kg	30	86	2580
Organic fertilizer	Kg	3,750	2	7500
Household labor	M.D	206	240	49440
Capital cost	-	-	-	690
(3) Total N.V.I.C				60210
Fixed costs				
Small agr. equipment	-	-	-	1317
(4) Total F.C				1317
(5)Total variable input cost (2+3)				67110
(6)Total costs (2 + 3 + 4)				68427
(7)Gross Margin[Monetary] (1- 2)				87700
(8)Total Gross Margin (1 – 5)				27490
(9)Net Margin (1– 6)				26173
Returns to family labor per day[(a)]				367
Remuneration rate (8/5 * 100)				41%

(a) Returns to family labor per day = (Net Margin + Monetary value of household labor)/ Quantity of household labor.

Table B-22: Sorghum budget for Bugesera agricultural zone, Modules 2, Kigali rural province, Rwanda(per hectare).

ITEMS	UNIT	QUANTITY	UNIT PRICE	Module 2a (Frw)	Module 2b (Frw)
PRODUCTION					
-Grain	Kg	1,820	86	156520	
	Kg	2591	86		222826
(1)Gross revenue				156520	222826
Monetary variable input costs					
Mineral fertilizer (NPK)	Kg	250	222	55500	
Mineral fertilizer (DAP)	Kg	110	200		22000
Mineral fertilizer (Urea)	Kg	80	219		17520
Organic fertilizer		7,750	2	15500	
Hired labor (module 2a)	M.D	26	300	7800	
Hired labor (module 2b)	M.D	25	300		7500
Seeds	Kg	30	86	2580	2580
Pesticide (Dursiban)	Kg	20	250	5000	5000
(2) Total M.V.I.C				86380	54600
Non-monet. variable input costs					
Organic fertilizer	Kg	3,750	2	7500	7500
Household labor (module 2a)	M.D	231	240	55440	
Household labor (module 2b)	M.D	230	240		55200
Capital cost	-	-	-	8638	5460
(3) Total N.V.I.C				71578	68160
Fixed costs					
Small agr. equipment	-	-	-	5033	5033
(4) Total F.C				5033	5033
(5)Total variable input cost (2+3)				157958	122760
(6)Total costs (2 + 3 + 4)				162991	127793
(7)Gross Margin[Monetary] (1- 2)				70140	168226
(8)Total Gross Margin (1 – 5)				-1438	100066
(9)Net Margin (1– 6)				-6471	95033
Returns to family labor per day[(a)]				212	653
Remuneration rate (8/5 * 100)				-0.9%	82%
V/C ratio[(b)]				0.9	3.2

(a) Returns to family labor per day = (Net Margin + Monetary value of household labor)/ Quantity of household labor.

(b) v/c ratio = (Gross revenue module 2 - Gross revenue module 1)/ (Total mineral and organic fertilizer module 2 – Organic fertilizer module 1)

Table B-23: Margins in Bugesera agro-ecological zone, Kigali rural province, Rwanda,2001.

	Sorghum
GM1	87,700
TGM1	27,490
NM1	26,173
GM2a	70,140
TGM2a	-1,438
NM2a	-6,471
GM2b	168,226
TGM2b	100,066
NM2b	95,033

Source: Grouped from crop budgets in tables B-21 to B-22

Notes:
GM1= Gross margin for Traditional module
TGM1= Total gross margin for traditional module
NM1= Net margin for traditional module
GM2= Gross margin for Improved techniques
TGM2= Total gross margin for improved techniques
NM2= Net margin for improved techniques

Table B-24: Cost shares in Bugesera/Mayaga agro-ecological zone, Kigali rural province, Rwanda, 2001 (percentage).

	Sorghum M1[(a)]	Sorghum M2a[(b)]	Sorghum M2b[(c)]
Mineral fertilizer	0	34.5	31.3
Organic fertilizer	10.9	14.3	5.9
Hired labor	10.0	4.6	5.9
Small agr. equipment	1.9	3.2	4.0
Pesticide	0	3.1	4.0
Seeds	3.8	1.6	2.1
Household labor	72.2	33.2	42.3
Capital cost	1.2	5.5	4.5

Source: Computed from crop budgets in tables 21 and 22

Notes:

(a) Traditional modes of production.
(b) Improved agricultural techniques (with NPK).
(c) Improved agricultural techniques (with DAP + Urea).

Table B-25: Returns to Family labor per day for selected crops with traditional (M1) and improved practices (M2) in Kigali rural province, Rwanda, 2001(FRW)

	Plateau de l'Est	Plateau central	Bugesera
Beans M1	184	102	-
Climbing beans M2a	11	-113	-
Climbing beans M2b	172	-41	-
Sorghum M1	304	164	367
Sorghum M2a	169	-67	214
Sorghum M2b	323	373	653
Soybeans M1	235	73	-
Soybeans M2a	-	-	-
Soybeans M2b	371	286	
Maize M1	412	197	-
Maize M2a	451	75	-
Maize M2b	-	207	-

Source: Grouped from crop budgets in tables B-1 to B-8, B-11 to B-18 and B-21 to B-22

Note: Normal agricultural wage = 300Frw/day

Table B-26: Remuneration rate for selected crops with traditional (M1) and improved practices(M2) in Kigali rural province, Rwanda, 2001(Percentage)

	Plateau de l'Est	Plateau central	Bugesera
Beans M1	-15	-40	-
Climbing beans M2a	-35	-54	-
Climbing beans M2b	-12	-53	-
Sorghum M1	21	-21	41
Sorghum M2a	-7	-40	0.6
Sorghum M2b	21	30	82
Soybeans M1	0.1	-47	-
Soybeans M2a	-	-	-
Soybeans M2b	28	12	
Maize M1	55	-11	-
Maze M2a	32	-23	-
Maize M2b	-	-5	-

Source: Grouped from crop budgets in tables B-1 to B-8, B-11 to B-18 and B-21 to B-22

M1: Traditional modes of production.
M2: Improved agricultural techniques.

APPENDIX C
AGRICULTURAL CALENDA

Table C-1: Agricultural calendars for the three major agricultural zones of Kigali rural Province
(Adapted from "Calendriers culturaux", MINAGRI 1986)

AGRICULTURAL ZONE	DISTRICTS	CROP	SEASON A						SEASON B					
			Sept.	Octob.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.
Bugesera & Mayaga	Gashora	Beans	////////// ######				xxxxxxxx	//////////			ooooooooooo xx	xxxxx		
	Ngenda	Peanuts	//// //////////				xxxxx xxx		/// //////////			xxxxxx		
	Nyamata	Soybeans	//// //////////			xxxx	xxxxxx	//////////			xx	xxxxx		
		Sorghum					//////////					xxxxxxxxxx		
		Maize	/// //////////				xxxxxx							
		Rice	xxxxxxxxxxxx			//////////	//////////				xxxxxx //////////	//////////		
		Sweet potato	xxxxxxxxxxxx //////////	//////////			##########		//////////	//////////	ooooooooooooo		xxxxxxxx	
		Cassava	//////////	//////////	harvesting after 18 months				//////////	//////////	harvesting after 18 months			
		Banana	//////////	//////////	harvesting is gradual				//////////	//////////				

"///" = seedling or planting ; "xxx" = harvesting period; "ooo"= seeding or planting and harvesting; "###"=harvesting in marshland

Table C-1 cont.

AGRICULTURAL ZONE	DISTRICT	CROP	SEASON A						SEASON B					
			Sept.	Octob.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.
Plateau central	Rushashi Shyorongi Buliza Rulindo	Beans	//////// ////////xx	//////		xxxxxx	xxxxxx		////////	//////		xxxxxx ////////		xx
		Peanuts	//////	/////			//////	xxxxx ///////	xx		xxxxx			
		Soybeans	//////	//////			xxxxxx		//////////			xxxx		
		Sorghum				//////	///////	xxxxxx				xxxxxx	///////	
		Maize	/////	//////		///	xxxxxx ///////					xxxxx		
		Peas		//////////			xxxxxxx		//////////			xxxxxx		
		Sweet potato	xxxxxx //////////	###### xxxxxx //////////	######				xxxxxx //////////	xxxxxx //////////	xxxxxx ooooooo	ooooo		
		Potato	##### //////////			xxxxx	xxx		//////////			ooooo xxxxx		
		Cassava	//////////	//////////	harvesting after 18 Months to 2 years				//////////	//////////	//////////	harvesting after18 months to 2 years		
		Bananes	//////////	//////////	harvesting is gradually done				//////////	//////////				
		Colocasia	//////////	//////////						xxxxxx	xxxxxx			

"///" = seedling or planting ; "xxx" = harvesting period; "ooo"= seedling or planting and harvesting; "###"=harvesting in marshland

Table C-1 cont.

AGRICULTURAL ZONE	DISTRICT	CROP	SEASON A						SEASON B					
			Sept.	Octob.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.
Plateau de l'Est	Gasabo Bicumbi	Beans	////////// #####	//////////		xxx xxxxxx xxxxx		//////////			oooooooooo xxxxxxxx			
		Peanuts		//////////			xxxxxxxxxx	//////////	//////////			xxxxxx		
		Soybeans		//////////			xxxxx	////////!	//////////			xxxxxx		
		Sorghum					//////////					xxxxxxxxxx		
		Maize		//////////			xxxxxxxx							
		Peas	//////////				xxxxxxx							
		Sweet potato	xxxxxxxxxxxx //////////	//////////		##############			xxxxxxxxxxxxxxxxxx //////////	//////////	oooooooooooo	xxxxxxxxxx		
		Rice			xxxxxxxxxx	//////////	//////////				xxxxxxxxxxxx	//////////	//////////	
		Cassava	//////////	////////!	harvesting after 18 months				//////////	//////////	//////////	harvesting after 18 months		
		Bananas	//////////	////////!	harvesting is gradual			////////!	//////					
		Colocasia	//////////	//////////						xxxxxxxxxxxx				

"///" = seedling or planting ; "xxx" = harvesting period; "ooo"= seedling or planting and harvesting; "###"=harvesting in marshland
Source: Adapted from MINAGRI(FAO/PASAR), Calendriers culturaux, 1986

APPENDIX D

HOUSEHOLD CHARACTERISTICS

Table D-1: Age and gender of the household head for the three major agro-ecological zones, Kigali rural province, Rwanda, 2001 (Percentage)

	Less than 19 years	from 20 to 60 years	more than 60 years	Total
		Plateau de l'Est		
Male	0	60	0	60
Female	0	33	7	40
Total	0	93	7	100
		Bugesera		
Male	3	58	3	63
Female	0	29	8	37
Total	3	87	11	100
		Plateau central		
Male	0	49	9	58
Female	0	33	9	42
Total	0	82	18	100

Source: Estimated from MINAGRI (FSRP/DSA) survey data (2001)

Table D-2. Level of education of the household head for the three major agro-ecological

zones, Kigali rural province, Rwanda, 2001 (Percentage of total households in the agro-ecological zone).

Level of education	Agro-ecological zone								
	Plateau de l'est			Bugesera			Plateau central		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Illiterate	17	37	53	29	24	53	39	31	70
Never in school but literate	3	0	3	3	3	5	6	3	9
Some elementary School	30	0	30	11	8	18	3	6	9
Complete elementary school	10	3	13	21	3	24	3	3	6
Some High school	0	0	0	0	0	0	6	0	6
Total	60	40	100	63	37	100	58	42	100

Source: Estimated from MINAGRI (FSRP/DSA) survey data (2001)

Table D-3: Distribution of farmland area per household by quartile (in hectares), Kigali rural province, Rwanda, 2001

Agro-ecol. zone	Quartile 1		Quartile 2		Quartile 3		Quartile 4		
	% of Land	Average area per HH	% of Land	Average area per HH	% of Land	Average area per HH	% of Land	Average area per HH	Overall Mean
Plateau de l'Est	5	0.26	14	0.74	28	1.36	53	2.84	1.30
Bugesera	8	0.36	14	0.7	31	1.08	47	2.05	1.05
Plateau central	5	0.31	12	0.67	21	1.35	62	3.99	1.58
Kigali ngari Province	6	0.3	14	0.66	26	1.21	54	2.7	1.22
Rwanda	5	0.17	12	0.4	23	0.79	61	3.44	0.86

Source: Estimated from MINAGRI (FSRP/DSA) survey data (2001)

Table D-4: Distribution of farmland area per household adult equivalents by quartile (in Hectares), Kigali rural, Rwanda, 2001.

Agro-ecological zone	Quartile 1		Quartile 2		Quartile 3		Quartile 4		
	% of Land	Average area per HH	% of Land	Average area per HH	% of Land	Average area per HH	% of Land	Average area per HH	Overall Mean
Plateau de l'Est	5	0.07	14	0.15	26	0.29	56	0.70	0.30
Bugesera	7	0.09	19	0.20	27	0.33	47	0.57	0.30
Plateau central	6	0.08	12	0.15	20	0.28	63	0.89	0.35
Kigali ngari province	6	0.08	15	0.16	24	0.29	55	0.65	0.30

Source: Estimated from MINAGRI (FSRP/DSA) survey data (2001

APPENDIX E

LAND USE PATTERNS AND CROP PRODUCTION

Table E-1. Land use by farm size in the Plateau de l'Est agro-ecological zone, Kigali rural, Rwanda, 2001 (% 0f cultivable land)

	FARM SIZE QUARTILE (Ares*/AE)				
	<13	13 - 25	26 - 40	>40	All Farms
Legumes	30	28	27	21	27
Cereals	17	10	17	8	13
Roots and Tubers	19	28	22	23	23
Bananas	14	23	20	21	20
Coffee	1	0	4	2	2
Other crops	0	1	1	1	1
Total cultivated	81	89	91	76	84
Fallow	19	11	9	24	16
Pasture	0	0	0	0	0
Woodlot	0	0	0	6	2
Other uses	7	7	7	5	7

Source: Estimated from MINAGRI (FSRP/DSA) survey data (2001)

Note:
* 100 ares = 1 hectare

Table E-2: Land use by farm size in the Bugesera/Mayaga agro-ecological zone, Kigali rural province, 2001.

% OF CULTIVABLE LAND	FARM SIZE QUARTILE (Ares/AE)				All Farms
	<13	13 - 21	22 - 61	>61	
Legumes	33	18	20	29	25
Cereals	16	14	22	16	17
Roots and Tubers	34	34	27	19	29
Bananas	5	8	7	10	8
Coffee	1	2	1	3	2
Other crops	0	0	1	3	1
Total cultivated	90	76	78	80	81
Fallow	10	24	22	20	19
Pasture	0	0	0	0	0
Woodlot	0	0	0	0	0
Other uses	7	3	5	3	5

Source: Estimated from MINAGRI (FSRP/DSA) survey data (2001)

Table E-3: Land use by farm size in the Plateau central agro-ecological zone, Kigali rural, Rwanda, 2001

% OF CULTIVABLE LAND	FARM SIZE QUARTILE (Ares/AE)				All Farms
	<11	11 - 20	21 - 31	>31	
Legumes	28	22	24	22	24
Cereals	13	11	9	11	11
Roots and Tubers	23	26	28	24	25
Bananas	26	23	21	14	21
Coffee	4	3	6	4	4
Other crops	1	7	2	6	4
Total cultivated	95	94	89	82	90
Fallow	5	6	11	18	10
Pasture	0	0	4	0	1
Woodlot	1	0	6	11	4
Other uses	11	6	4	4	6

Source: Estimated from MINAGRI (FSRP/DSA) survey data (2001)

Table E-4: Crop shares by farm size in the Plateau de l'Est agro-ecological zone, Kigali rural, 2001.

% OF CULTIVATED LAND	FARM SIZE QUARTILE (Ares/AE)				All Farms
	<13	13 - 25	26 - 40	>40	
Beans	37	36	33	29	33
Peas	1	0	1	1	1
Peanuts	2	1	2	0	1
Soybeans	0	0	0	0	0
Total Legumes	39	37	36	30	35
Sorghum	21	7	19	10	14
Maize	2	6	3	1	3
Total Cereals	23	13	21	11	17
Cassava	7	9	13	12	11
White potato	4	5	4	11	6
Sweet Potato	13	21	10	14	14
Taro	0	2	1	4	2
Total Roots and Tubers	25	37	27	40	33
Banana	12	13	12	16	14
Coffee	1	0	2	1	1
Other Crops	0	1	1	1	1

Source: Estimated from MINAGRI (FSRP/DSA) survey data (2001)

Table E-5: Crop shares by farm size in the Bugesera/Mayaga agro-ecological zone, Kigali rural, Rwanda, 2001

% OF CULTIVATED LAND	FARM SIZE QUARTILE (Ares/AE)				All Farms
	<13	13 - 25	26 - 40	>40	
Beans	29	19	24	31	25
Peanuts	9	3	1	8	5
Soybeans	0	3	3	2	2
Total legumes	39	25	28	41	32
Sorghum	16	16	21	17	18
Maize	3	4	9	5	5
Total cereals	19	20	30	22	23
Cassava	23	29	23	11	21
White Potato	2	0	0	2	1
Sweet potato	15	18	13	11	14
Taro	0	0	1	2	1
Total Roots and Tubers	40	47	36	26	37
Banana	3	6	4	6	5
Coffee	1	2	0	2	1
Others Crops	0	0	1	4	2

Source: Estimated from MINAGRI (FSRP/DSA) survey data (2001)

Table E-6: Crop shares by farm size in the Plateau central agro-ecological zone, Kigali rural province, Rwanda, 2001

% OF CULTIVATED LAND	FARM SIZE QUARTILE (Ares/AE)				All Farms
	<13	13 - 25	26 - 40	>40	
Beans	26	26	30	27	28
Peas	3	2	1	3	2
Soybeans	0	2	1	2	1
Total Legumes	28	30	31	32	31
Sorghum	15	9	11	14	13
Maize	3	1	1	2	2
Total Cereals	18	10	12	16	14
Cassava	13	9	15	13	13
White Potato	2	2	2	2	2
Sweet Potato	15	14	15	16	15
Taro	0	3	6	2	3
*Total Roots and Tuber*s	30	28	38	34	33
Banana	18	19	13	8	13
Coffee	3	3	3	3	3
Other Crops	2	9	3	8	6

Source: Estimated from MINAGRI (FSRP/DSA) survey data (2001)

Table E-7: Annual crop production per household for main crops in Kigali rural province, Rwanda, Average 2000-2002.

	Agro-ecological zone					
	Plateau de l'Est		Bugesera		Plateau central	
	Quantity produced (kg)	Energy (kcal)	Quantity produced (kg)	Energy (kcal)	Quantity produced (kg)	Energy (kcal)
Beans	348	980,942	288	811,814	236	665,237
Sorghum	160	305,136	243	463,425	120	228,852
Maize	123	390,808	116	368,561	37	117,560
Cassava	1,307	1,403,718	1,333	1,431,642	752	807,648
Sweet Potato	1,072	1,355,973	1,005	1,271,225	992	1,254,781
Cooking Banana	847	29,349	278	9,633	221	7,658
Beer Banana	1,728	299,981	747	129,679	782	135,755
Table Banana	222	5,057	76	1,731	202	4,601
Peanuts	56	180,632	82	264,497	0	0
Other crops	333	254,745	255	195,075	495	378,675
Total kcal/year/HH		5,206,341		4,947,288		3,600,767
Total kcal/day/HH		14,261		13,554		9,865

Source: Estimated from MINAGRI (FSRP/DSA) survey data (2000, 2001 and 2002)

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