RESEARCH REPORT

85

COMMERCIALIZATION OF AGRICULTURE UNDER POPULATION PRESSURE: EFFECTS ON PRODUCTION, CONSUMPTION, AND NUTRITION IN RWANDA

Joachim von Braun
Hartwig de Haen
Juergen Blanken

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FOREWORD

Rapid population growth in agroecologies that are already under high population pressure poses a major challenge for development policy. It becomes an even greater challenge in complex agroecologies where little new technology for rapid agricultural expansion is available. The mountain zones of the Zaire-Nile Divide in Central Africa present an example of such a challenging environment where agriculture has encroached onto marginal zones, that is, water catchment areas and the last tropical forests of the area. This study by von Braun, de Haen, and Blanken highlights the potentials of agricultural development for the employment, income, and consumption of the poor, but also stresses that nonagricultural rural growth and employment expansion are key to improved food security and nutrition in this setting. The authors show that the delivery of public goods—health services, sanitation, and education—has to move ahead in order to maintain and improve the human capital foundation in this stressed environment.

The study is based on detailed primary household data utilized in innovative ways to assess the household's and farmer's (and her husband's) behavior in the subsistence economy vis-à-vis options for specialization. A number of interesting policy findings emerge, such as the poor being too poor to capture the gains from efficient specialization because they need to take care of subsistence-based insurance against hunger.

While generally favorable effects of commercialization of agriculture for nutrition are manifested by this study and preceding IFPRI studies on this topic, the present study also draws attention to the need for concern about land tenure when the stimulus for agricultural commercialization is given in a land-scarce environment.

Just Faaland

Washington, D.C.
January 1991

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The large data sets were handled in a most efficient way by Graciela Wiegand-Jahn, who also contributed greatly to the analysis and interpretation of results.

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We are indebted to the *bourgmestre* of Giciye *commune* for generously giving his support and office space. We are grateful for the efforts of the survey teams and for the patience of the household respondents who gave their valuable time.

Joachim von Braun
Hartwig de Haen
Juergen Blanken

1

SUMMARY

Increased market integration of traditional agriculture is part of a development strategy oriented toward growth. Integration in the local, national, and international exchange economies promises gains through specialization. But it is the design of programs and policies and their actual implementation that determine whether or not the poor obtain a fair, or even a positive, share of gains from agricultural commercialization, directly or indirectly. Gains for the poor are not a priori assured, and numerous cases quoted in the literature—though not well documented and frequently methodologically flawed—point to adverse effects of increased market integration on the welfare of the poor, including their nutrition.

This study, which is part of a larger effort at IFPRI, looks in detail into the effects of commercialization on production, income, employment, consumption, and nutrition. The study location is in Rwanda and is among Sub-Saharan Africa's most densely populated rural areas.

The specific objectives of this research are, first, to assess the effects of the interaction between increased commercialization and population growth on production, household real incomes, family food consumption, expenditures for nonfood goods and services, and the nutritional status of the population, and second, to develop a long-term perspective, based on household analysis, of the implications of this change for agricultural, infrastructural, employment, and nutrition policies.

The empirical analysis of the research is based upon a detailed survey of production, income and consumption, nutrition of individuals, and health in about 200 households. The survey was undertaken during 1985/86 in an area in the high-altitude zone of the Zaire-Nile Divide in northwestern Rwanda. The study area is very densely populated, and a high population growth rate (4.2 percent) increases the pressure. The study site also is undergoing agricultural commercialization induced especially by the introduction of tea production and the expansion of potato production for the market. While tea and potatoes play important roles in the overall commercialization of rural households via product and labor markets, other important forces identified by the survey are nonagricultural off-farm employment and home production activities, the latter especially referring to the brewing of sorghum beer as a more traditional form of commercialization.

The economic analysis of tea production in the study area concludes that the crop is not adding to aggregate income there, because competition with other crops (cereals, pulses, roots, and tubers) is strong, and established tea factory capacities are underutilized, leading to high fixed costs per unit of output. One parastatal tea factory in the study area responded to these efficiency problems by externalizing costs: smallholders were expropriated and land was added to the factory-managed plantation to reach higher-capacity utilization. Such an aberration of commercialization and the finding of lack of comparative advantage of tea are departures from the generally successful introduction of tea into Rwanda's economy.

Commercial potato production in the area is done in a former natural forest area (Gishwati forest), partly on licensed plots obtained from a reforestation project on a temporary basis and partly in an uncontrolled form without such entitlements. This potato production is concentrated in larger holdings—that is, in the context of this smallholder system, on farms with more than 1.5 hectares. The average farm size in the sample is 0.7 hectare per household. While central to current employment and household food availability, potato production in the forest area—a key water-catchment area—poses risks to sustainability of the production environment in the longer run.

Agriculture in the study area is still very subsistence-oriented. On average, 67.5 percent of the value of agricultural production is consumed by the households, thus aggregate marketed surplus is 32.5 percent. Sorghum beer and potatoes account for about 30 percent each of agricultural sales, and the remaining 40 percent is from livestock, tobacco, tea, and occasional sales of subsistence crops such as sweet potatoes and sorghum.

Yet a look at agriculture alone would give a biased impression of overall rural commercialization. The great majority of farm households have sizable nonagricultural incomes. Off-farm income is on average 57.5 percent of total income, and in the smallest farm-size quartile it reaches 80.1 percent. Off-farm employment is largely found by men, while women do most of the fieldwork. Women account for 74.1 percent of family labor input in agriculture. Only in single-crop potato production with modern inputs do men contribute an important share of labor input. A significant share of the work force on the tea plantations—mainly for plucking—consists of women (19 percent in 1985). So far, this is the only significant off-farm employment of women in the area.

Subsistence orientation—that is, the share of own-produced food in total per capita food and nonfood consumption—is remarkably stable across different farm sizes and per capita income levels. The value of own-produced food in percentage of the total value of food and nonfood consumption is on average 47.8 percent. Multivariate analysis shows that, all else holding constant, this value shrinks by only 1.3 percent with a 10.0 percent increase in land scarcity (person-land ratio).

Although options for gains from commercialization and specialization appear to exist, the poor farmers in this setting forgo them to a large extent because of the need for food insurance (subsistence). They are thus too poor to opt for an "efficient" production pattern. Yet from their household perspective, efficient resource utilization—including that for food insurance—needs to be factored in.

The critical development issues in this very densely populated region relate to employment and labor productivity. Gross margins per labor day for major crops in 1985/86 ranged between US$0.44 for sorghum in mixed cultivation and US$0.71 for sweet potatoes and were about US$0.60-0.70 for potatoes and maize. Econometric estimates point to the interesting finding that increased land scarcity in the study area, due to the rapid population growth (4.2 percent a year in the 1980s), can still be substantially compensated for by intensification of labor and capital input per unit of land. The indigenous mechanisms for increasing labor productivity under increased land scarcity are found to be sizable: a 10 percent increase in the person-land ratio results in only a 3.6 percent decline in labor productivity. While this is encouraging, given the already extremely high person-land ratio in the area (5.5 adult-equivalent persons per hectare), it also stresses the increased need for technological change.

The major proportion of incremental income that households earn is spent on food. For an average household a 10 percent increase in income leads also to a 10 percent increase in the consumption value of food, and to an increase of 5 percent in calorie consumption. Richer households spend much more for a more diverse diet. Consequently, households in the top per capita income quartile spend 77 percent more per calorie than households in the poorest income quartile.

Hunger, that is, calorie deficiency, is a problem in a large proportion of households. Calorie consumption has only a weak link to farm size but a strong one to income. In mid-1986, 41 percent of the households consumed less than 80 percent of recommended requirement levels—a commonly used critical cutoff point below which calorie consumption levels are seriously deficient. Among the calorie-deficit households is a large share of those who were continuously in deficit over the survey period (about 60 percent of the deficit households). In these households in particular, the nutritional status of children deteriorates, and increased growth retardation and underweight are in fact diagnosed for the children. In the total sample population in 1986, 21.5 percent of all children below 7 years of age are identified as stunted (below 90 percent of the height-for-age standard), and 12.3 percent are substantially underweight (below 80 percent of the weight-for-age standard). Scarcity of subsistence food, cash, and time impinges on the nutritional outcome. Time constraints of adults—that is, women in the most resource-poor households—lead to a shift of labor demand to children for the production of home goods, such as fuelwood collection and water fetching. Children fulfill these tasks to a much larger extent in calorie-deficient households than in others.

Increasing household calorie consumption is important but alone does not solve the nutritional status problem. The effects of the health environment and household sanitation on children's anthropometric status are very substantial. Doubling household calorie consumption from 1,500 to 3,000 calories per adult-equivalent—an extreme change indeed—would reduce stunting by about a quarter of a standard deviation (or 17 percent of the Z-score mean), whereas a worm cure would have the same effect, and a clean latrine would have twice this impact on nutritional status. This underlines the role of improved health services, accessible to the poor, in nutritional improvement. Richer households spend substantially more on health care than the poor (calorie-deficient households) can afford.

Long-term simulations with a demographic model stress the important role of the area's rapid population growth in the rural transformation process during the next two decades. The rapidly rising person-land ratio is expected to further increase intensification of food crop production with higher labor inputs per unit of land. A substantial absolute and relative expansion of sweet potato production stands out as a result and points to the importance of an increased focus on technological change in this crop.

In a rapidly increasing share of rural households, self-sufficiency in staple foods will drop very fast within the coming decade. The person-land ratio in the area will increase from 5.5 adult-equivalent persons per hectare in 1985 to 12.0 per hectare in 2005. Most dramatic is the labor-supply expansion for nonagricultural employment that will, even under cautious assumptions in the simulations, more than double from its already high level.

2

RESEARCH OBJECTIVES

Commercialization of the rural sector is considered a cornerstone of successful economic development. It allows increased participation of individuals and households in the domestic and international exchange economy. Through realization of comparative advantages, it is supposed to benefit not only individual rural families but also the agricultural sector and the whole economy.

Commercialization may have many facets in this context. Generally speaking, it describes an individual's or a household's economic transactions with others. These may be both in cash and in kind, the latter playing a considerable role in many traditional communities. Transactions may relate to agricultural produce, indicating that a certain proportion of a farm's output is not produced for subsistence but for sale. They may also relate to inputs, indicating that a farm's production technology depends to a certain extent on external inputs. Finally, a household may also be commercialized by earning off-farm income, mostly from labor employment outside the household, but possibly also from capital investment.

Evidently, all these transactions will not only enable a rise in a family's or an individual's income; they may also improve the nutritional situation, provided there is a preference for better nutrition and provided the individuals are able to express these preferences and get access to increased food supplies. While the first condition—high preference for food—will be mostly fulfilled, the latter—realization of preferences and market access—may not in cases of market failure or policy failure. In fact, a survey of research findings concerning the effect of commercialization in agriculture on the alleviation of poverty, on the distribution of food, and on the nutritional status of vulnerable groups has shown mixed results (von Braun and Kennedy 1986).

Insufficient food consumption to meet nutritional requirements is closely related to poverty, and a significant portion of increasing incomes among the poor would be expected to be spent on more food. If low-income farmers and landless laborers capture at least part of the economic surplus generated by shifts from subsistence to cash crop production, and if a portion of these people are malnourished, one would expect that the nutritional status would improve. Conceptually, these relationships are, however, not straightforward, and a review of the literature showed that results from past studies do not provide satisfactory answers (von Braun and Kennedy 1986). As will be shown below, complex farm and rural household production-consumption relationships need to be understood and quantified in order to address these relationships properly for policy conclusions.[1]

This research has two objectives. First, to assess the effects of increased commercialization on production, household real incomes, family food consumption, expenditures for nonfood goods and services, and the nutritional status of the population in an

[1]Studies into the issue by Kennedy and Cogill (1987) in Kenya, von Braun, Puetz, and Webb (1989) in The Gambia, and von Braun, Hotchkiss, and Immink (1989) in Guatemala show generally positive net effects of commercialization for nutrition, or at least no adverse effects.

environment under severe population pressure. Second, to describe the process by which household food consumption and nutritional status are affected by increased commercialization, identifying the most important elements of the process and estimating how each element is influenced by the change. The analysis should form a basis for evaluating the alternative short- and long-term options for the design of policies and programs to cope with possible income and nutrition problems in the process of transformation from semisubsistence to more commercialized agriculture.

This study—undertaken in a very densely populated location in northwestern Rwanda—forms part of a larger research effort at IFPRI on the policy questions posed by the commercialization process in traditional agriculture. While an integrative study of several studies is also currently being undertaken for more generalizable conclusions, each of the studies offers in-depth insight into the causes and consequences of commercialization in different socioeconomic and ecological environments. This study is located in an area that is unusual on a number of counts—it has an extremely high population density, an extremely high population growth, and an extremely low degree of urbanization, and is extremely landlocked in the center of Africa. The authors argue that it is particularly revealing to study such an "extreme" case in order to derive insights for future policy directions. In this case, this argument applies especially to the changes induced by the high level of rural population density and its rapid growth.

There is an urgent need to improve the understanding of the development process in densely populated areas under increased population pressure, such as the study region, where there is little new agricultural production technology. Also, the interaction between agriculture and the rest of the rural economy especially requires further research. It can be hypothesized that a higher population density makes possible more rapid attainment of gains from specialization and the emergence of a rural service sector. Moreover, high population density may limit the number of households able to survive from agriculture alone, thus forcing some into nonfarm activities to supplement income (Haggblade and Hazell 1987).

A central research issue for this study location under population pressure is the sustainability of agricultural production systems along with the efficient use of the resource base. A long-term view of options and alternatives is required for this issue (Tisdell 1988). Much effort has been made to develop sustainable agricultural production systems in Rwanda (Kotschi, Pfeiffer, and Grosser 1982), yet their attractiveness to small farmers has remained rather limited. To understand and overcome adoption problems, experimental work in the field of sustainable systems should start at the farm level and include assessment of short- versus long-run costs and benefits to farmers and the economy (Adelhelm and Kotschi 1985). While the present study acknowledges this critical requirement, it adds the dimensions of household production-consumption relationships and farm-nonfarm sector links, which are of central importance to agricultural technology adoption in subsistence farming.

3

THE FORCES DRIVING THE COMMERCIALIZATION PROCESS

Underlying Structures and Policies

Rwanda is among the most densely populated countries in the world, and its population density expressed in terms of inhabitants per square kilometer is very high (about 246 persons per square kilometer in 1987). The country is landlocked in the center of Africa, with long road transport routes across neighboring Burundi and Tanzania or Uganda and Kenya to the nearest seaports—Mombasa, Tanga, or Dar es Salaam. The related high transportation costs are almost prohibitive for the integration of bulky commodities into the international exchange economy. For instance, transport costs for cereals from Rwanda to seaports (for example, Mombasa) exceed normal f.o.b. world market prices. Thus, export and import parity prices of cereals in Rwanda establish a range between negative and more than twice the long-term average of the c.i.f. East Africa coast price.

Failure of the domestic market to get access to international food markets is a reality for this landlocked country, as crises in neighboring countries occasionally block the trade routes. Consequently, Rwandan food policy emphasizes high national self-sufficiency and increasing regional market integration (Rwanda, Ministry of Planning 1983).

The Rwandan economy is only weakly integrated into the international exchange economy. The value of merchandise exports represents only 8 percent of gross domestic product (GDP). For a landlocked country, an extremely low proportion of exports goes to neighboring regions: 81 percent of all exports found their way to the industrial market economies in 1985 (Table 1) (Sinamenye 1986). The economy as a whole appears to be quite subsistence-oriented, which is further suggested by the extremely low degree of urbanization (only 5 percent of the population lives in urban centers). The share of agriculture in GDP, however, was substantially reduced during 1965-85, from 75 percent to 45 percent. This change in the share of agriculture clearly indicates a substantial increase in internal diversification and specialization, including rural nonagricultural activities.

In comparison with other African countries, Rwanda has not incurred very high debts and was therefore not much affected by the debt crisis of the 1980s. Debt service in percentage of total exports stood at only 4.3 percent in 1985, a low burden for the economy. In income per capita (gross national product [GNP]), Rwanda ranks among the 25 poorest developing countries. Life expectancy at birth is even below the average found in low-income economies (for selected indicators, see Table 1).

So far, Rwanda's integration into the international exchange economy has been largely based on agricultural exports, specifically coffee and, more recently, tea. In 1985, coffee composed 65 percent and tea 15 percent of total exports from Rwanda. Yet export crops and nonfood cash crops cover only a minor share—5.6 percent in 1983—of total arable land in the country. At the aggregate, food availability per capita appears to have

Table 1—Some basic features and long-term trends of Rwanda's economy, 1965-85

Item	1965	1985	1965-85 Average
Population (millions)	3.2	6.1	...
Population growth (percent/year)	...	...	3.1
Urban population (percent)	3.0	5.0	...
Gross national product (US$/capita, in 1985 dollars)	195	280	...
Growth of GNP per capita (percent/year)	...	...	1.8
Share of agriculture in GDP (percent)	75.0	45.0	...
Exports (merchandise) (percent of GDP)	n.a.	7.6	...
Share of total exports to industrial market economies (percent)	96.0	81.0	...
Debt service (percent of exports)	n.a.	4.3	...
Share of coffee and tea in total exports (percent)	n.a.	79.8	...
Official development assistance (percent of GNP)	n.a.	10.7	...
Calorie supply (per capita/day)	1,665	1,919	...
Infant mortality rate (per 1,000 children below 1 year)	141	127	...
Life expectancy at birth (years)	n.a.	48	

Sources: African Development Bank, *Selected Statistics on Regional Member Countries* (Abidjan: ADB, 1987); World Bank, *World Development Report* (Washington, D.C.: World Bank, 1987); International Monetary Fund, *International Financial Statistics* (Washington, D.C.: IMF, 1987).

Note: n.a. means not available.

increased over recent decades.[2] This growth was largely a result of the expansion of land area into marginal zones (Delepierre 1985). The population density in terms of persons per hectare of cropland has increased by 30 percent since the early 1960s and stood at more than eight persons per hectare in the mid-1980s (Table 2).

With a population growth of 3.3 percent a year in the 1980s, the already very limited land base becomes more and more a constraint to agricultural growth and income generation. The obvious way out of this dilemma appears to be a combination of policies that will lead to reduced population growth, increased land productivity through technological change in agriculture, conversion of land resources, and increased exploitation of the potentials of specialization in the rural economy. Investments in rural infrastructure, education, and technological change in agriculture should be the key inputs. Providing improved understanding of the potentials and the constraints in fostering this process is a main task of this research.

The diversity of the country and of the region cannot be captured by a case study for just one location. However, the microlevel processes of commercialization studied at the

[2]It should be noted that such assessments are made on the basis of rather weak food production and trade statistics (African Development Bank 1987; World Bank 1987; International Monetary Fund 1987).

Table 2—Total arable land area, land use for export crops, and population density in Rwanda, 1961-83

Item	1961	1973	1983
Arable land (1,000 hectares)	521	610	750
Export crops and nonfood cash crops (percent of arable land)	4.6	5.1	5.6
Population density (persons/hectare of arable land)	6.2	6.5	8.1

Sources: Computed from FAO Production Yearbooks and African Development Bank statistics.

location may be generalized under certain conditions. These processes and the responses of the households to them are the main interests of this study.

The Study Area

The research for the present study was conducted in the *commune* of Giciye, which is situated in the *préfecture* (district) of Gisenyi in the northwestern part of Rwanda (Figure 1). Some survey work also was done in the neighboring *commune*, Karago. The following description focuses on the main study area in Giciye *commune*.[3]

The total area of Giciye *commune* is estimated at 185 square kilometers, approximately 120 square kilometers of which are suitable for agricultural production, the remainder being part of the former natural forest of Gishwati.

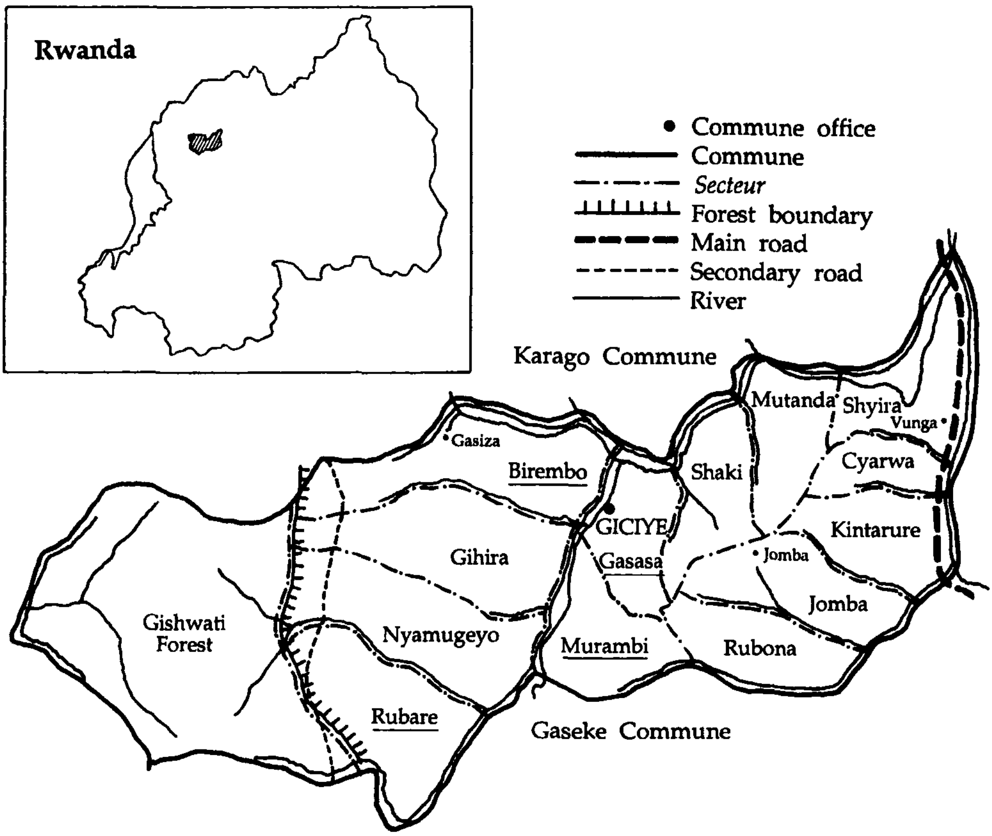
Before the *communes* are described in more detail, some explanation should be given to better understand what a *commune* is in Rwanda. Since the administrative reform of 1974, a *commune* can be regarded as the lowest governmental and administrative unit, with a *bourgmestre* as the official government representative. The *bourgmestres* are nominated by the country's president. The *commune* is further subdivided into *secteurs*, which again are subdivided into *cellules*. A *cellule* normally consists of some 100 families.

Agroecological Zone Characteristics

Following the classification of Rwanda into the agroecological zones given by Gotanègre, Sirven, and Prioul (1974) and Jones and Egli (1984), the study area belongs to the agroecological zone of the Central Zaire-Nile Divide that passes through Rwanda from north to south, with the agroecological zones of the Kivu Lakeshore to the west and the High Plateaus to the east. The main characteristics of the Central Zaire-Nile Divide are relatively high altitudes, normally exceeding 2,000 meters, low average annual temperature of approximately 15°C, and abundant precipitation averaging 1,300 millimeters a year (Jones and Egli 1984). In the study area, altitude increases rapidly from 1,500 meters in the east, at the border of the High Plateaus region, to approximately 3,000 meters at the summit of the Gishwati forest, with most of the communal area situated at more than 2,000 meters.

[3]The following description of the study area is mainly based on the 1984 annual report of Giciye *commune*.

Figure 1—Map of the study area



Note: The underlined *secteur* names are those of the four *secteurs* selected for the study.

During 1983-85, annual precipitation averaged 1,236 millimeters, which is rather low because 1984 was a drought year with rainfall of only 948 millimeters or 68 percent of the amount in normal years (1,380 millimeters). However, because of the prevailing temperature and moisture regimes, the risk of crop failure due to changing climatic conditions may be considered generally low. Since this is an equatorial region, the distribution of rainfall follows a bimodal pattern. Four climatic seasons can be distinguished: a long rainy season from mid-February to late May; a long dry season from the end of May to mid-September; a short rainy season from mid-September to early or mid-December; and a short dry season until mid-February.

Another important characteristic of this agroecological zone is its mountainous relief dominated by very steep slopes of up to 30°-40°, causing severe surface soil erosion. In fact, soil erosion due to the deforestation and transformation of former forest and pastureland into permanent arable farmland will be one of the most important problems of future development of farming systems in the study area.

Soils are generally very poor and acid, mainly derived from metamorphic rocks like granites, schists, and gneisses. The analysis of a soil sample of 90 farm plots undertaken for this study revealed a high degree of soil acidity and a general deficit of phosphorus. In some higher-altitude areas of the *commune*, soils are found to be aluminum toxic, thus prohibiting normal crop production, with the exception of tea, which can stand this level of aluminum concentration.

The output mix of farms in the various agroecological zones shows a high degree of variety—a major problem for setting commodity priorities for agricultural innovations. This is exemplified in Table 3, which shows the crop production per farm in the two *préfectures*, Ruhengeri and Gisenyi, each broken down by agroecological zone. The differences in importance of bananas, potatoes, and coarse grains for the various agroecological zones are particularly pronounced.

Population

According to the population census, the total population of Giciye *commune* was 52,236 at the end of 1984. The average annual increase between 1978 and 1984 was 4.2 percent. The composition by age groups reveals a high population share (46.2 percent) for the group below 18 years of age and only 5.2 percent for that above 60 years of age.

In 1984 the composition by ethnic groups in the *commune* was Hutu (98.8 percent) and Tutsi (1.0 percent), the remainder being Twa, the pygmy aborigines. Average population density was 282 persons per square kilometer in 1984, or 435 persons when only the area suitable for agricultural production is taken into account. However, population density varies considerably among the different administrative sectors of the *commune*, from approximately 270 persons per square kilometer in some higher-altitude *secteurs* in the west to more than 900 persons per square kilometer on the volcanic soils at the border of the High Plateaus in the east.

Markets and Social Infrastructure

There is only one main road (*route principale*) that crosses the communal area of Giciye (Figure 1). This road descends for a distance of 24 kilometers from Giciye to Mukamira, an important marketplace situated at the paved road that links the provincial capitals of Gisenyi and Ruhengeri to the capital, Kigali.

The area is equipped with two health centers in the Karago *commune*, and one in Giciye attached to a hospital. Another hospital is located in the neighboring Kabaya *commune*.

In Giciye, there are 19 primary schools spread throughout the *commune* area. In Karago, there are 14 primary schools and 2 secondary schools.

In both *communes*, there is a *centre communal de développement et de formation permanente* (CCDFP), with branch centers for some *secteurs*. The main activities of the CCDFP are in the fields of literacy campaigns, improvement of agricultural practices, hygiene, and family planning. The centers work in close collaboration with the local cooperatives.

Giciye *commune* has three markets of different size and importance: a market takes place twice a week in Gasiza, Jomba, and Vunga (Figure 1). Kabaya is another important marketplace situated at the border of Giciye and Gaseke *communes* in the south of the study area.

Using the typology of Rwandan agricultural markets developed by the national agricultural research organization (*l'Institut des Sciences Agronomiques du Rwanda* [ISAR]), Jomba and Gasiza may be classified as *marchés paysans*—that is, relatively small rural markets of only local importance—where farmers themselves constitute the majority of sellers and buyers. The number of merchants and middlemen organizing the

Table 3—Product mix in different agroecological zones in and around the study area, 1984

Prefecture/ Zone	Altitude	Farm Size	Persons per Household	Annual Production per Farm: Beans	Peas	Potatoes	Sweet Potatoes	Sorghum	Maize	Bananas
	(meters)	(hectares)					(kilograms)			
Ruhengeri										
Lava earth	2,000	0.87	5.2	214	39	1,493	157	394	401	564
Zaire-Nile Highlands[a]	1,950	0.87	5.3	191	74	108	476	44	49	1,385
Buberuka Highlands	1,950	1.13	5.6	386	132	143	841	275	226	1,404
Central Plateau	1,837	0.87	4.9	219	14	4	794	17	63	2,327
Gisenyi										
Lake Kivu border	1,733	0.85	6.3	272	2	0	280	13	28	2,657
Zaire-Nile Highlands[a]	2,356	1.33	3.9	71	119	676	626	179	424	112
Central Plateau	1,750	0.57	6.2	125	3	0	501	0	20	915

Source: Rwanda, Ministry of Agriculture, Animal Husbandry, and Forestry (computed from primary farm data, Enquête Nationale Agricole), Kigali, 1985.

[a]The data for the Zaire-Nile Highlands zone (above 2,000 meters) are most comparable to the survey done specifically for this study in Giciye *commune*. It should be noted that the data from Ruhengeri *prefecture* in this zone include some farms below 2,000 meters that are already in the banana-growing zone.

interregional exchange of agricultural products of different agroecological zones is limited to a very few in this type of market.

On the other hand, Kabaya and, in particular, Vunga can be classified as *marchés collecteurs*, markets of medium to high importance in the interregional exchange of agricultural produce. Vunga, in the eastern part of the study area, is one of the most important markets of the whole northern region of Rwanda; 75 percent of the total number of traders registered in Giciye *commune* are found in Vunga.

Sources of Rural Commercialization

The commercialization process in the study area reveals itself in the changing income sources of households and changing patterns of employment in the rural communities. The commercialization process occurs partly on the basis of indigenous sources of nonagricultural employment, cash crops, and manufacturing activities. Processing of beer from sorghum is the main commercialization activity of the indigenous type. Among the new sources of commercialization, the production of tea and the expansion of potato production have the primary positions. Finally, increased off-farm employment generated by project activities in the community has acquired increased importance. Before these sources of commercialization are traced in detail at the household level, background information at the regional and community levels is provided in the following sections. Special attention is paid to the role of tea because of its importance in the national context.

Expansion of Tea Production

Tea Production in the National Context. In Rwanda the introduction of tea goes back to the early 1950s when some private settlers started tea production more or less on an experimental basis. In 1957, the acreage under tea was estimated at approximately 200 hectares, and the crop was further processed in neighboring factories of Uganda and Zaire. The construction of the first Rwandan tea factory in Mulindi began in 1960. However, it was not until independence in 1962 that tea production started to expand on a larger scale, following two feasibility studies financed and partly carried out by the European Development Fund in 1961/62.

The main rationale in giving priority to tea production was seen in a diversification of agricultural production, export crop production in particular, because the Rwandan economy depended almost entirely on the export of coffee. Expansion of rural employment for the rapidly growing population was another motive for the promotion of tea production. The very promising performance of tea production in neighboring countries, particularly in Kenya, further encouraged the introduction of tea (Lamb and Muller 1982).

The rapid expansion of the acreage under tea during the early stages was not detrimental to food crop production. The establishment of tea production schemes took place mainly by clearing and planting former forest land in the high-altitude regions of the Central Zaire-Nile Divide and by draining and cultivating large, formerly uncultivated swamps in lower-altitude areas. The total acreage devoted to tea grew from approximately 285 hectares in 1962 to 10,120 hectares in 1984 (Table 4). Still, in 1984, tea acreage represented only 0.8 percent of total arable land.

Table 4—Total and harvested tea areas, production of dry tea, and yields of dry tea per hectare in Rwanda, 1962-85

Year	Total Area	Harvested Area	Production of DryTea	Yield of Dry Tea
	(hectares)		(metric tons)	(kilograms/ hectare)
1962	285	n.a.	n.a.	n.a.
1967	1,000	799	518	648
1971	3,087	2,144	1,819	848
1975	5,496	3,459	3,995	1,155
1978	7,537	5,915	4,859	821
1979	8,393	6,635	5,230	788
1980	8,876	7,315	5,910	808
1981	9,221	7,470	6,845	916
1982	9,506	7,392	7,050	954
1983	10,449	7,991	7,584	950
1984	10,120	8,229	8,708	1,058
1985	9,970	8,826	11,332	1,284

Source: Annual reports of *l'Office des cultures industrielles du Rwanda-thé* (OCIR-Thé), Rwanda.
Note: n.a. means not available.

The production of dry tea grew from 518 metric tons[4] in 1967 to 8,708 tons in 1984, or by 18.1 percent annually. The total value of tea exports in current prices increased from approximately FRw 190 million in 1972 to FRw 1,587 million in 1985, thus contributing approximately 12-13 percent of the total value of all exports since 1977 and lessening significantly the heavy dependence of the Rwandan economy on coffee exports.

Tea in the Study Area. In the study area, initiation of tea production started in the mid-1970s with the establishment of the factories at Rubaya in 1975 and Nyabihu in 1976. However, it was not until 1980/81 that the factories were completed and the production of dry tea began. The Rubaya factory is located close to the Gishwati forest in Gaseke *commune* at the southwestern border of Giciye *commune*. The factory's processing capacity is 1,200 tons of dry tea per year. Tea production is based on both plantation and smallholder schemes. Table 5 reveals that in Rubaya, smallholder tea accounted for approximately 70 percent of the total harvested area but for only 48 percent of total production in 1985. The harvested area under smallholder tea has been unstable in the past and has declined since 1981. While smallholder yields in kilograms of dry tea per hectare and year are far below the Rwandan average for this category, the respective yields for plantation tea are exceptionally high and above the Rwandan average. Given the large share of smallholder tea in the total harvested area and the extremely low productivity of the smallholders, the rate of utilization of the processing capacity was only 38 percent in 1985.

It should be emphasized that the establishment of Rubaya plantation took place mainly by clearing and planting formerly uncultivated parts of the Gishwati forest and that it was not detrimental to food crop production, except for some 38 hectares of expropriated farmland with a total of 43 families that have been compensated. They were able to resettle nearby.

[4]All tons in this report are metric tons. Dry tea is the manufactured product when it leaves the factory.

Table 5—Harvested area and production of plantation and smallholder tea for Rubaya and Nyabihu factories, 1980-85

Factory	1980	1985
Rubaya		
Plantation tea		
Harvested area (hectares)	84	150
Production of dry tea (metric tons)	62.4	241.5
Yield of dry tea (kilograms/hectare)	743	1,610
Smallholder tea		
Harvested area (hectares)	332	342
Production of dry tea (metric tons)	39.4	220.2
Yield of dry tea (kilograms/hectare)	119	644
Nyabihu		
Plantation tea		
Harvested area (hectares)	150	416
Production of dry tea (metric tons)	47.4	332.1
Yield of dry tea (kilograms/hectare)	316	798
Smallholder tea		
Harvested area (hectares)	18	30
Production of dry tea (metric tons)	2.1	24.2
Yield of dry tea (kilograms/hectare)	117	807

Source: Records of tea factories in Rubaya and Nyabihu.

The Rubaya factory maintained some 180 hectares of eucalyptus forest in the Gishwati area in 1985 to provide its own firewood for tea processing. The plantation currently extends into the Gishwati area, and the objective is to have 600 hectares of tea plantation and another 250 hectares of forest by the year 1990.

The Nyabihu factory is situated in Karago *commune* and has a capacity of 800 tons of dry tea per year. Nyabihu production is based almost exclusively on plantation tea, with smallholder tea accounting for 15 percent of the total acreage and 6.7 percent of the harvested area in 1985. The yields were almost identical for Nyabihu smallholder and plantation tea in 1985, but the plantation yield was only about 50 percent of that at Rubaya.

While the Rubaya plantation consists almost entirely of tea planted on hillsides, the composition of the total area of the plantation at Nyabihu in 1985 was approximately 43 percent on hillsides, the remainder being swamps.

Except for a very few hectares of forest close to the factory, Nyabihu does not use its own forest resources for firewood and must either buy the bulk of its firewood on the local and regional markets or work with electricity, both of which are very costly.

In contrast to Rubaya, the expansion of the tea plantation at Nyabihu partly took place by taking over smallholder cropland in 1983/84. In order to utilize established factory capacities, and as smallholder tea was not forthcoming because of poor profitability (see next section), costs of fixed capital—the factory—were "externalized," thus displacing farmers. Their farm area has since been devoted to plantation tea. The household-level effects of this expropriation are analyzed in Chapter 6.

Profitability of Tea Production. The profitability of tea production varies considerably among locations and factories, depending on the respective costs of production and processing, the local prices, and the profitability of alternative options of land and labor use.

In terms of costs of production and collection in Rubaya (as in some other factories), there seems to be a clear advantage for plantation tea compared with smallholder tea. Yields on the Rubaya plantation are among the highest in the country, which is a consequence of efficient management. On the other hand, yields on smallholder fields in Rubaya are among the lowest in the country.

The average costs of processing are twice as high in Rubaya (FRw 168 per kilogram of dry tea) and Nyabihu (FRw 130 per kilogram) as the average for the country (FRw 69 per kilogram). Part of this wide gap may be due to technological and managerial reasons.

A calculation of revenues (prices per kilogram minus total costs of production, processing, and domestic marketing) applied to the average of the two factories in Rubaya and Nyabihu[5] results in a negative economic return, independent of whether official or shadow exchange rates are used. However, the estimated economic profitability changes considerably if one assumes a drastic increase in the rate of capacity utilization and a reduction of processing costs corresponding to those achieved elsewhere in Rwanda.

In general, the economic analysis suggests that the procurement prices paid at farm level in the study area have been implicitly subsidized. In other words, if the factories had paid break-even prices, the financial profitability at farm level would have been significantly lower than that realized by farmers in the past.

Yet even at this implicitly subsidized price level, a clear comparative advantage in land and labor productivity does not seem to exist for smallholder tea production in the study area. Only a limited number of successful tea growers are able to obtain gross margins per person-day in the range of competing food crops, which stood around US$0.60 per day for sole stands of maize and US$0.70 for potatoes. The majority of the farmers find food production more attractive and tend to abandon tea insofar as administrative controls do not prevent them from doing so, or if not, an input for maintenance and harvesting is provided by the factories.

In summary, while smallholder tea production in Rwanda generally appears profitable and contributes efficiently to foreign exchange generation, this is clearly not the case in the study area. High processing costs due to underutilization of established factory capacities is the main reason, and the high unit cost of production of green tea in smallholder cultivation is the second factor. Full utilization of factory capacities would require expansion of the tea area at the cost of subsistence food production in this location. The opportunity costs of tea-production expansion are high and the consequences for household-level food security in the area require attention. Chapters 5 and 6 evaluate this in further detail.

Expansion of Potato Production

In recent years, potato production has expanded rapidly in northwestern Rwanda, especially in the zone of the volcanic highlands, where environmental conditions are very favorable for potato production. In this region, market infrastructure—for potatoes in particular—is fairly well developed along the asphalted road linking Gisenyi and Ruhengeri. Along this road a large number of traders engage in potato marketing; they not only handle the interregional trade in potatoes by supplying all potato-deficit regions of Rwanda (and exporting to Zaire and Burundi as well) but have also set up an efficient input-provision network to supply farmers with knapsack-sprayers, pesticides, and

[5]The tea price of Rubaya factory is used here.

improved seeds. (Scott [1986] provides a very useful description of the potato market situation in the area.) Potato production was further encouraged in the region by the installation of the *Programme National pour l'Amélioration de la Pomme de Terre* (PNAP) in Ruhengeri in 1979, with the support of the International Potato Centre (CIP). The main activities of PNAP are the selection, production, and distribution of improved varieties and extension.

For Giciye and Karago *communes*, the acreage of potatoes was 8 percent and 38 percent, respectively, of total cropped area. There seems to be a tendency toward increasing acreages and yields of potatoes in the area. It has to be noted that these figures are only estimates of potato production on farmers' own fields and do not take into account the extent of potato production in the Gishwati forest area. The latter is a special case of potato production and a major source of recent commercialization in the study area.

Farmers and project employees of a reforestation and pasture-improvement project supported by the World Bank (GBK project) in the area cultivate potatoes, almost exclusively in sole stands, within the cleared and reforested areas of the former natural forest. Also, potato production has expanded rapidly into those parts of the forest that are outside the GBK project area. Potato production in the Gishwati region has a tremendous impact on the total potato production in the study area and on rural employment creation and food prices. The household-level data from the survey reported below provide further insights on this specific force of commercialization in the study area. Farmers from distant *secteurs* in the surrounding *communes* cultivate potato plots in the forest. Some of the plots are acquired through temporary leases from the reforestation project; others are occupied informally.

Brewing of Sorghum Beer

An indigenous and important source of commercialization in rural areas of Rwanda is the manufacturing of sorghum beer and banana beer. In the survey area, only the sorghum beer is produced to a significant extent. Throughout Rwanda, there are an estimated 560,000 home brewers of sorghum beer (Haggblade and Minot 1987). The income, employment, and food consumption effects of sorghum beer brewing appear quite significant. Most of this brewing is done by women as a home production activity. Much of the produce is marketed. Sorghum beer production is affected by sorghum availability and labor availability, which leads to a somewhat seasonal pattern of beer brewing. Sorghum beer volumes are highest immediately after the sorghum harvest. Nationwide data indicate that sorghum beer brewing is more or less equally distributed across rural income groups. Home brewers in the bottom and top income quintiles each provide about 21 percent of total sorghum beer production (Haggblade and Minot 1987). The IFPRI survey results show that for this study area the importance of sorghum beer sales for total agricultural sales remains more or less the same across farm-size classes, and income from sorghum beer production is negatively but not significantly correlated with total income.

In the study area, sorghum beer sales represent about one-third of total sales of farm produce (in 1986) and contribute substantially to net farm income. Increased sorghum beer sales are highly correlated with an overall increase in marketed surplus. There is, however, substitution between wage earnings and home brewing of sorghum beer; the two are significantly negatively correlated in the household samples, which are reported in more detail below. Employment generation is significant for a population group—women—that does not participate very much in off-farm employment.

Off-Farm Employment

Among the more important formal employers in the area, by order of importance, are the already-mentioned GBK reforestation project in the Gishwati forest; the two tea factories; the German development assistance project (*Projet d'Intensification des Productions Vivrières* [IPV]); road construction and infrastructure schemes; public works activities; and various activities of nongovernmental organizations.

As will be argued on the basis of primary household-level data below, off-farm nonagricultural employment is of considerable importance for commercialization in the study area, and much of this employment is directly or indirectly linked to specific development assistance projects. The rise and fall of projects creates a fair amount of instability in the rural labor market, an issue that requires further analysis.

After a brief discussion of the theoretical foundation, research design, and data collection for this research in the following chapter, detailed household-level results and respective analyses are presented.

4

THEORETICAL FOUNDATION, RESEARCH DESIGN, AND DATA BASE

Basic Relationships

The effects of commercialization on income and nutrition are mediated through complex relationships at the household level. Generally speaking, improvement of a household's or a person's nutritional status has to come through the ability to acquire more food, hence through growth of income or of resource endowments or both. An expected increase of income and production capacity is what motivates a household or individual household members to enter the exchange economy and become more commercialized. Thus, insofar as increased sale of produce, purchase of inputs, and off-farm employment occur on a voluntary basis, and insofar as the responsibilities and preferences within a household ensure sharing of gains, it can be expected that commercialization contributes to the household's food security.

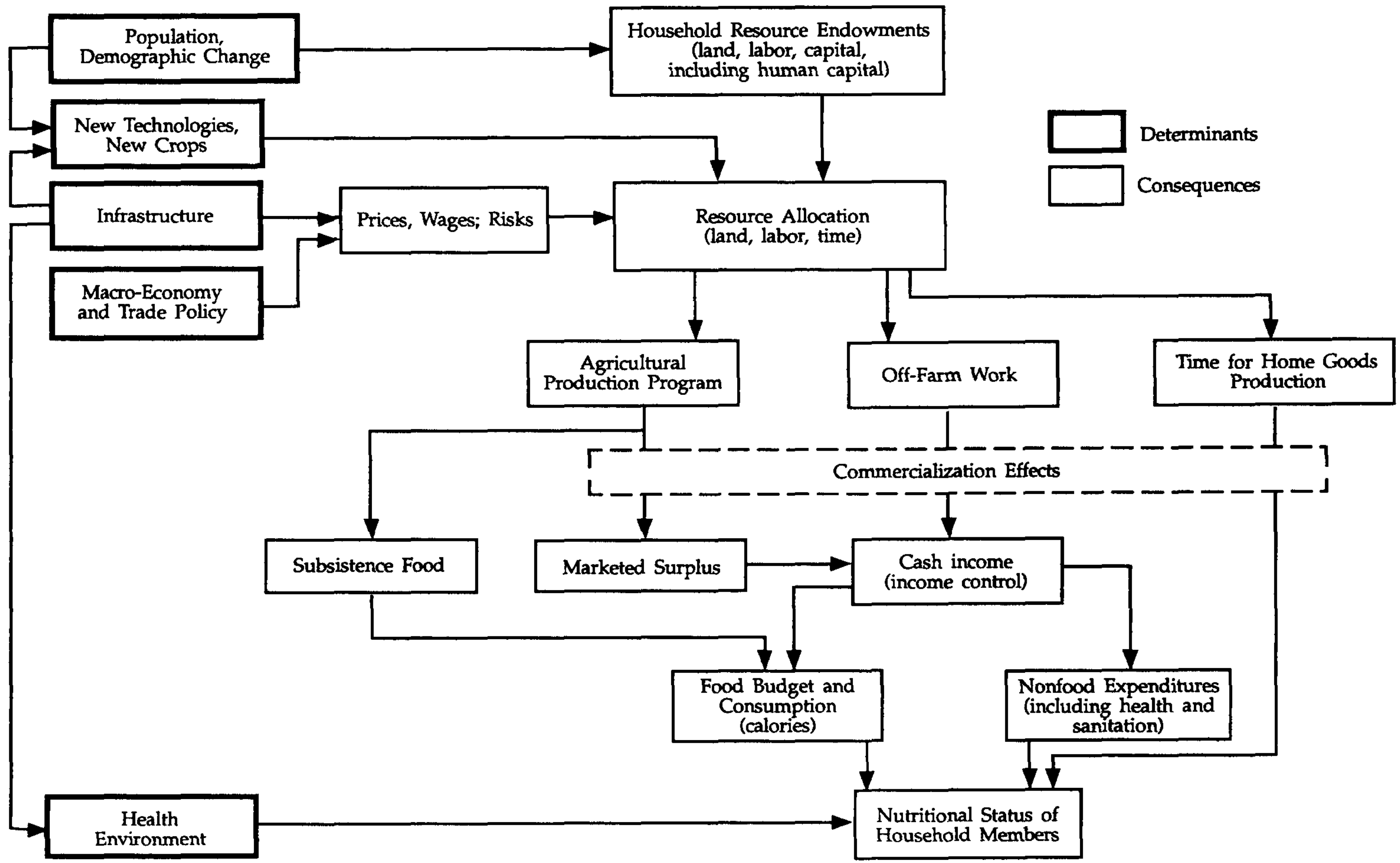
Yet the relationship is more complex when it comes to the real world of rural households, often characterized by structural imbalances, institutional constraints, and permanent changes of internal as well as external conditions. In spite of dynamic interdependencies of causes and effects, it may facilitate the analysis if exogenous factors that determine the commercialization are separated from the endogenous factors that tend to affect the influence of commercialization on income and nutrition. Figure 2 describes major relationships between both groups of factors.

Concerning the exogenous determinants of commercialization (left-hand side of Figure 2), among the most important driving forces are population change, availability of new technologies, markets and infrastructure, overall economic growth, and, finally, government policy related to these. Some of these factors may have more immediate and others only long-term effects on the farmer's decision to become more integrated in the market.

Demographic change is certainly a key determinant in the long run. It may facilitate or impede the commercialization of products, depending on the availability of resources. If an expansion of the cultivated area is still possible, so that the marginal labor productivity exceeds the marginal subsistence requirements, population growth may in fact enable an increase of the marketable surplus. Yet this situation has certainly become rare. Under the conditions in Rwanda, and with no significant change in the people's preference for a high degree of self-sufficiency in staple food, it is not unlikely that population growth might lead to a reduced volume of marketed surplus in relative or even absolute terms. On the other hand, it is likely that an increased person-land ratio might lead to an increased demand for off-farm employment in order to generate cash income, of which a high proportion will be spent on food.

The availability of new technologies, improved seeds and agronomic practices, on the one hand, and investment in infrastructure, price incentives from extended demand for agricultural products, and attractive wages and employment opportunities, on the other, are the other factors that facilitate the commercialization process. Of course, the second

Figure 2—Commercialization at the household level: determinants and consequences for income, consumption, and nutrition



group is closely related to the performance of the overall economy. Finally, commercialization can also be promoted by direct government action; namely, by various forms of compulsion related to the establishment of plantations (for example, tea or coffee), execution of certain management practices and input use, or forced procurement of produce.

The endogenous consequences of commercialization are also indicated in Figure 2. They relate to three different levels of decisionmaking within the households. One affects the allocation of the increased income for food and nonfood expenditures. It may be hypothesized that a reduced share or a reduced absolute volume of subsistence production will motivate a rise in the volume of purchased food and vice versa. The second decision level relates to how the available food budget is actually spent, that is, which types and which quantities of food are purchased and how these purchases are distributed over the year. Finally, the third decision is on how the available food is distributed among household members.

To understand how these decisions may be affected by the commercialization process, one has to consider other indirect consequences of commercialization, such as changes in the time allocation of men and women and in the control over the household's resources and cash income. For instance, it is not unlikely that—because of men's engagement in market production or off-farm work—women have less time for child care and home-based work and less control over the household's resources. Since men and women and younger and older people have different preferences in the allocation of a household's income for health care and nutrition, it is quite conceivable that commercialization may affect the situation of various family members differently, depending on how it changes the allocation of time, responsibilities, and control over income within a household.

Explaining the Transition—Potentials and Deficits of Household Theory

The complexity of the relationships just described suggests that a comprehensive model of the rural household would be helpful in deriving hypotheses about the process of transition from subsistence toward full market integration. In fact, since Tschajanow (1923) first developed a theory of subjective household equilibrium, many authors have refined the model of the peasant household.

According to Tschajanow, a peasant family does not try to maximize a monetary profit but a subjective utility. Maximum utility is reached when the marginal drudgery of family labor in various activities is equated with the marginal goods and services gained from the labor input. Stimulated by Tschajanow, Nakajima (1970, 1986) developed a set of much more sophisticated subjective equilibrium models that basically postulate the same behavioral rules, with and without exchange with the external labor market. Nakajima not only specified a more formal mathematical structure that made it possible to trace the consequences of external changes, such as variations of wages, prices, and productivities on the household's labor allocation; he also specified certain properties of a family's indifference curves with a lower limit of income ("minimum subsistence") below which leisure has zero marginal utility and an upper bound ("achievement standard of living") above which income generated from further work has a marginal utility of zero. Nakajima's models describe the decision of household members to be engaged in wage employment or to employ hired labor in the farm household. Unfortunately, the models do not explicitly describe the factors that influence a household's decision concerning the allocation of resources between subsistence and market production. In essence the subjective equilibrium models assume a fully commercialized farm where a price can be imputed to all commodities.

In order to model the commodity side of the transition process, it would not only be necessary to introduce the distinction of subsistence and market production at the level of resource use, including labor; it would also be necessary to specify the underlying causal determinants, such as risk aversion, tasks, and habits, that may motivate a household to maintain a certain degree of self-sufficiency even at the cost of market income forgone. Moreover, nonmarketable household goods and services as well as market goods would have to have a common nonmonetary utility index.

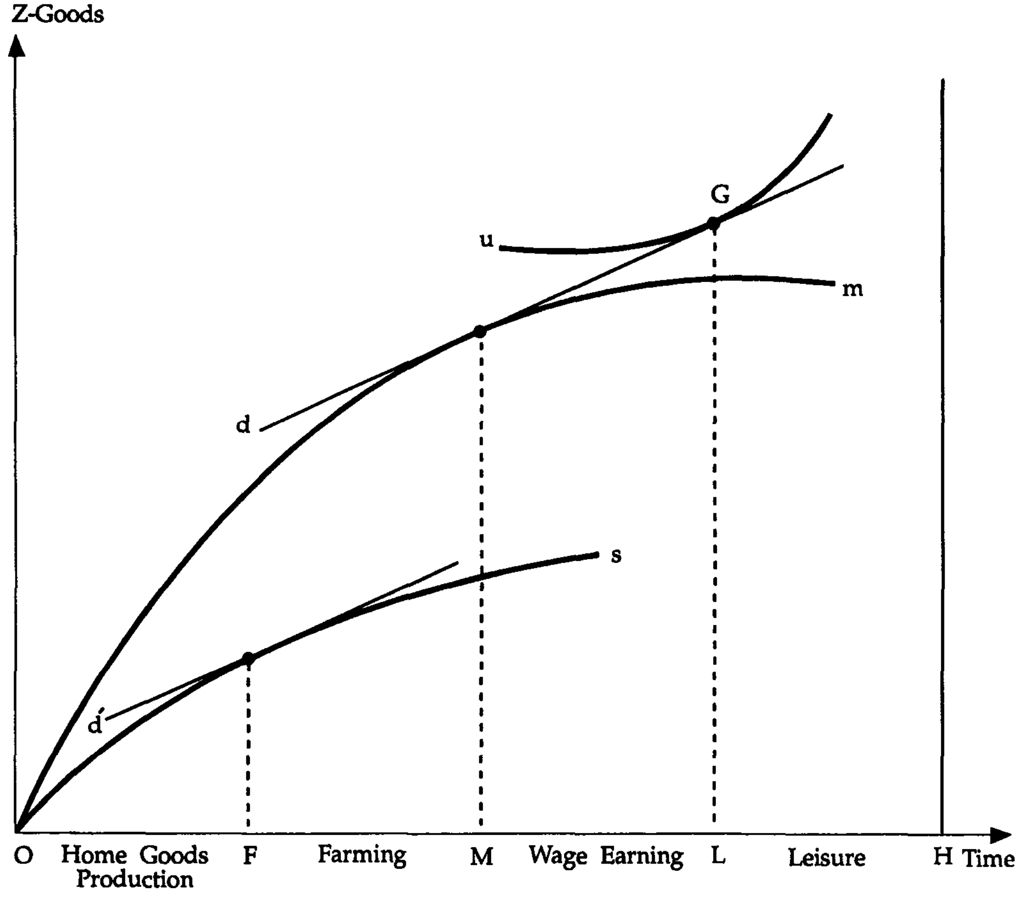
Fisk (1975) concludes from this that it is impossible to impute a price to a commodity that a farmer produces to meet his own family's needs without even considering exchanging it at the market. Fisk therefore postulates a complete separation of a subsistence enterprise and a monetary enterprise, whereby a household would first seek to maximize its utility in terms of physical subsistence goods and then, in a second step, allocate the remaining labor (and related resources) so that it maximizes its utility in terms of monetary income and leisure. Fisk is aware of dynamic forces that tend to reduce the marginal utility of subsistence production, namely, the establishment of effective local markets for agricultural and nonagricultural commodities, but also of changes in a household's consumption preferences and production technology. Thus "the subsistence component as a separate enterprise will tend to fade away" (Fisk 1975, 72). Yet this transition toward one unique monetary enterprise is not modeled explicitly.

The specification of a household's utility function in nonmonetary terms is one of the strengths of the modern theory of household economics, originating from Becker (1965) and Lancaster (1966). Models based on this theory postulate that a household's utility function is directly specified by a set of household-produced goods. These so-called Z-goods are produced by use of market or home-produced physical commodities in combination with the time input of household members. Maximization of a household's utility subject to a full-income constraint is then equivalent to minimizing the costs of producing a set of Z-goods, including leisure.

Using Evenson's (1978) application of this theory to a model of a peasant household, it seems in fact possible to include even the part of the subsistence production from household resources that cannot be used to produce market goods. This would normally include house and shelter, cooking facilities, and maybe a small home garden.

Figure 3 portrays the basic structure of the model. The composite Z-good is measured along the vertical axis, whereas the horizontal axis measures the working time, with the remainder of the full-time capacity (OH) being leisure. The curve s traces the production function for home goods, and curve m describes the combined production function of the household where agricultural production is added on the home production function. The basic assumption is made that the composite Z-good can be produced at home or purchased in the market. Purchased goods might not be identical but would be close substitutes for home-produced Z-goods. Thus the line d measures the opportunities in terms of Z-goods offered by the labor market. Its slope is defined as the wage rate divided by the goods price, indicating the purchasing power of the off-farm wage in terms of Z-goods (d′ is the parallel to d). Finally, u shows the indifference curve in terms of Z-goods and leisure.

Figure 3—Allocation of household time between home goods production, farming for the market, wage earning, and leisure



At equilibrium the household would have LH leisure time and LG Z-goods for consumption. It would spend OF units of time (and corresponding household resources) for home goods production, FM units of time for farm production, and ML units of time for wage earning. Thus the model postulates principally the same equilibrium conditions as the Nakajima-type model (Nakajima 1970, 1986): the marginal productivities of time in various activities in and outside the household are equated to the off-farm wage rate. But in addition, the physical specification of the utility curve enables inclusion of the home production as an extra domain of time allocation. Interesting hypotheses can be derived from this simple model:

- Increasing the wage rate raises the opportunity costs and hence motivates a reduction of the volume of home as well as farm production. It increases the incentive to seek wage employment and, depending on the position of the indifference curve, may also affect the overall time allocation between work and leisure.

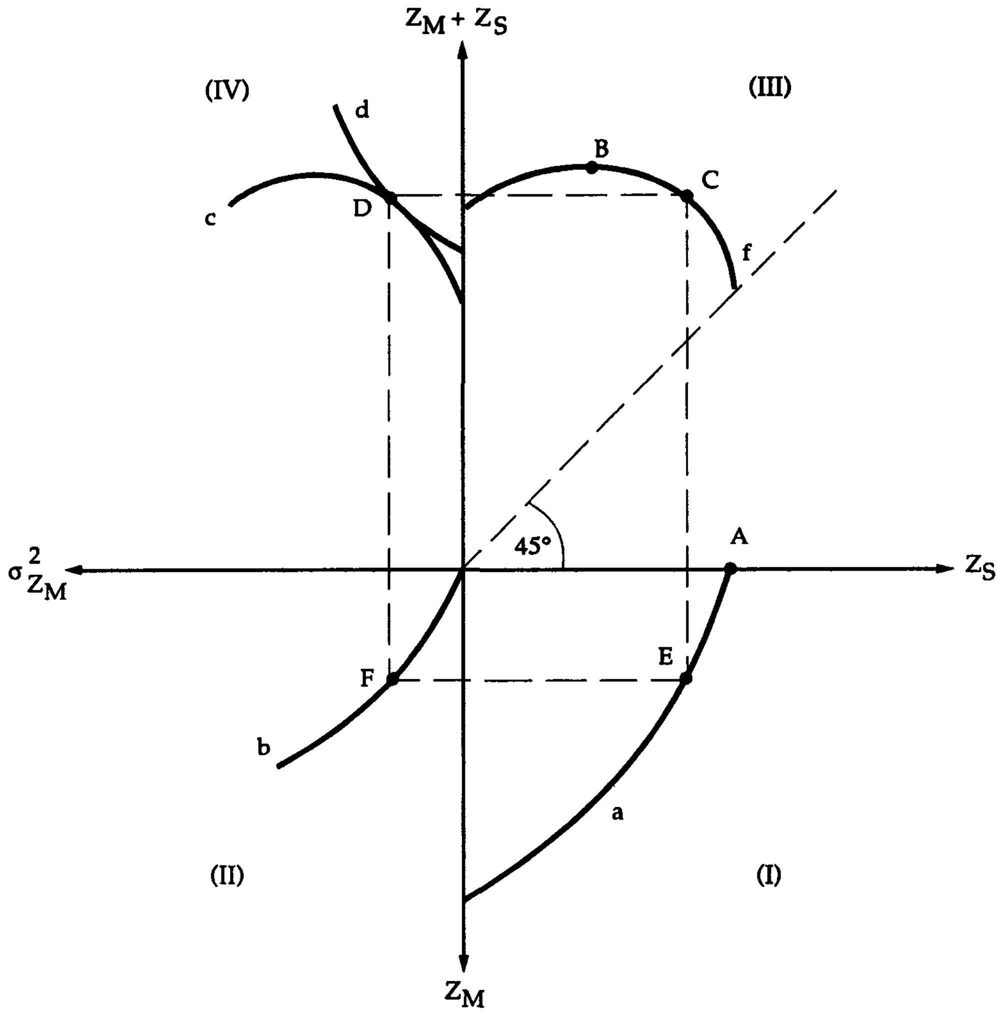
- Increasing the value of the Z-good reduces the purchasing power of the wage and therefore motivates an increase of the time spent in home production. Whether or not it also increases the time spent in farm production cannot be generalized on the basis of theoretical reasoning. It depends on the size of three separate effects: reduced opportunity costs of labor, increased price for the subsistence component of farm production, and reduced real price—that is, price expressed in Z-goods—for the market component of farm production. Thus the latter two may imply a shift of the farm production function.
- Increasing the productivity of farm work causes an upward shift of the overall production function. It motivates extended on-farm work and reduced off-farm work. Time allocated to home production is not affected unless the improved technology can also be applied on land—that is, home gardens—explicitly reserved for home production.
- Increasing the productivity of home goods production will also shift the combined production curve upward, but will mainly increase the time spent in the household and, depending on the shape of the home production curve, reduce either on-farm or off-farm work and possibly increase leisure.
- Increasing the family size will have complex implications for the household, depending on the effect on the labor force and the Z-good requirements, respectively. The impact on the demand for Z-goods includes needs for additional food, child care, and other household goods and services. This may increase the family's preferences for Z-goods instead of leisure. The effect on the family's labor force would, provided there exists a perfect labor market, essentially increase the family's demand for off-farm work and would not affect the internal time allocation. Yet, if additional employment cannot be found or can only be found at a reduced wage, the household would perceive reduced opportunity costs of labor and intensify the time spent in home and farm production.

In summary, there are a number of illuminating conclusions to be drawn from the model. Yet some of the aforementioned aspects of commercialization cannot be easily incorporated. Essentially the model assumes a complete separation of a family's resources for home production from those for farm production. Only the household's labor is being allocated between different types of activity. But the model does not explain how land and other resources are allocated to market and subsistence production. In order to derive preliminary hypotheses as to what motivates a household to adjust the share of resources determined for market production, the risks involved would at least have to be accounted for. Figure 4 portrays a simple model.

The household's production possibilities are indicated in section I of the figure. Curve a shows the transformation between Z-goods, namely food, that the household can directly produce for subsistence (Z_S), and Z-goods that the household can obtain by producing cash products and exchanging them for goods from the market (Z_M). Hence the curve's slope is not only determined by the physical production functions for subsistence and cash products, but also by the net price (gross margin) of the cash crop divided by the net price of the Z-good. Curve b (section II) indicates the market risks associated with an increased intensity of market exchange. Note that only those risks related to fluctuations of prices or availability of quantities are indicated here. Production risks are assumed to be identical in market and subsistence production. They do not enter the analysis.

Curve f (section III) represents the aggregate availability of Z-goods from subsistence and market exchange, as a function of the volume of subsistence production. The

Figure 4—Resource allocation to market versus subsistence production under risk



aggregate quantity is equivalent to the household's income. As the transformation curve is nonlinear, the aggregate has a maximum (B) somewhere between 0 and A—that is, at a degree of subsistence (subsistence divided by the total aggregate) between zero and one. Obviously, any extreme specialization on either subsistence or market production would be suboptimal due to declining marginal productivities (curve a). Finally, section IV portrays how the household might arrive at a decision concerning resource allocation for subsistence and market production by equating the marginal utility per unit of incremental aggregate production (curve c) with the marginal disutility due to the additional risks involved (curve d). A series of additional hypotheses can thus be derived about a household's decisionmaking:

- Risk-averse families may tend to keep subsistence production beyond the maximum income point (B)—say, at C, E— in order to keep the risk of market integration low (at F).
- A reduction of marketing risks—say, by improved infrastructure—(downward shift of curve b) and an increase of the profitability of marketing (downward turn of curve a through A) would both reduce the preference for a high degree of subsistence.
- Increasing a household's total resources (right shift of curve a) would most likely motivate a decline in the degree of subsistence, probably going along with an increased absolute volume of subsistence production.

In total, one can summarize that the available models of the rural household do not lead to a consistent specification of all basic relationships that were shown to be relevant for the commercialization process, but they do allow some important partial hypotheses insofar as the exogenous determinants of a farm's transition into the market is concerned. The state of model building and theory is still much less advanced when it comes to the endogenous factors that determine the allocation of income and the distribution of basic goods, food in particular, inside the household.

Analytical Approach

Some of the hypotheses derived from the preceding analysis will be subject to empirical tests in the following chapters. No attempt will be made to use a complete structural form of a household model for these empirical tests, since much information on important relationships would be lost in aggregation. Nor is a complete household model approach taken, partly because of the indicated deficits in modeling the complex interdependencies within rural households, but also because of limitations in data, especially data concerning marketing risks—which would require longer time series—and household preferences. Instead, the analytical approach comprises a set of equations describing the key relationships involved in the commercialization process. They relate to a household's time allocation, sources of income, spending of income, and determinants of the degree of subsistence. This degree will be measured following different concepts of market integration. Finally, the nutritional status of the rural family will be related to various factors that are subject to change during the commercialization process.

The actual analysis at the household level is carried out as sketched in Figure 2 in an attempt to trace some of the more relevant exogenous forces of commercialization to their effects on resource allocation, patterns of commercialization, consumption, and nutrition. Before discussing that, however, a clear specification of subsistence concepts will be given.

The term subsistence is used in two different ways. First, it is used as a concept that describes production of goods for consumption by the household. Second, subsistence is a concept that describes a minimum standard of physical and mental survival and productive efficiency (a comprehensive survey of literature on this concept is provided, for instance, in Sharif 1986).

In this study, the term subsistence is used in the sense of the first definition mentioned above. Accordingly, the term commercialization defines the volume of produce and household resources that enter the exchange economy. This may include sales or barter of farm products not used for subsistence and off-farm employment of labor and capital.

The extent of subsistence orientation and commercialization of farm households and the rural economy may be addressed from three different angles.

Agricultural subsistence orientation (concept 1) is measured by the extent to which farm households consume out of their aggregate agricultural produce as compared with the value of total agricultural produce:

$$CA = AS/AP, \qquad (1)$$

where CA is the agricultural subsistence ratio, which is the ratio of the value of non-marketed agricultural produce (AS) over the total value of agricultural production (AP).

In addition to this output-oriented concept, it can be imagined that subsistence agriculture develops toward "commercialization" on the input side but not on the output side; for instance, when farm households sell their labor in the off-farm labor market and invest proceeds in augmenting their subsistence production.

A more comprehensive concept of commercialization will take into account the overall degree of market integration of rural households into the exchange economy and does not just look into agriculture. This may be approached from two different angles, the income earning side and the consumption side.

Subsistence orientation at the income generation side of the household (concept 2), can be defined as follows:

$$CY = AS/Y_{tot}, \qquad (2)$$

with total income Y_{tot} being

$$Y_{tot} = AP - AC + Y_o + Y_w + Y_l, \qquad (3)$$

where

- CY = subsistence share in total income,
- AC = cost of agricultural production,
- Y_o = any other income from transfers or renting out assets (such as land),
- Y_w = off-farm wage income (from integration into the labor market), and
- Y_l = income equivalent of leisure.

Subsistence orientation at the consumption side (concept 3) may be evaluated with the ratio CX:

$$CX = X_s/X_{tot}, \qquad (4)$$

where CX is the subsistence share in total consumption, X_s is the total value of goods consumed out of home production, and X_{tot} is the total consumption value of the household, including purchased and own-produced items for consumption, such as the value of subsistence food.

The above measures (concepts 2 and 3) capture market integration/penetration of households beyond agricultural market integration. Landed rural households may commercialize through specialization in crop production or shifts in production functions through technical change combined with increased input demand (integration in input markets). Also, farm households may commercialize via increased off-farm work partly at the expense of marketed surplus from agricultural production. This means that there may be substitution effects between (AP - AC) and Y_w, leaving CY in equation (2) rather stable, with different patterns of subsistence orientation.

In fact, the sources of commercialization are manifold at the study location; the picture would be distorted if only the process of agricultural commercialization (concept 1) were presented here, as will be shown later. The process of commercialization of traditional agriculture is rarely just a switch from subsistence food to a cash crop, as already highlighted in the context of the descriptive account of the driving forces of commercialization in this study area.

Functional relationships, as depicted in Figure 2, are addressed in models that attempt to explain the key relationships. A simplified descriptive sketch of these models is given below. Details on specifications follow in the respective sections of the report.

Aggregate agricultural production (AGPROD), whether for the market or for home consumption, is a function of a household's resource endowments and technology. Thereby,

$$\text{AGPROD} = f(\text{Land, Labor, Capital, Technology, Environment}). \quad (5)$$

Total agricultural income may be derived from AGPROD and related prices and wages. Agricultural labor productivity of the household is thus a function of resource endowments, technology, and so forth.

The off-farm work time (OFFWORK) as a key choice of market integration at the study location is expected to be determined, among other things, by the off-farm wage rate versus agricultural labor productivity, as work time off-farm competes with time spent for on-farm production:

$$\text{OFFWORK} = f(\text{Off-Farm Wages, Agricultural Labor Productivity, Demographic Composition of Households, Location}). \quad (6)$$

It is of particular interest to trace the effects of commercialization and subsistence orientation to the household's budget for food and to calorie consumption levels (CALOR). This also tests for the effects of more integration into the cash economy on the level and composition of food consumption, which may be affected by changes in income control and income composition in the household:

$$\text{CALOR} = f(\text{Demographic Composition, Total Income, Food-Cash Ratio of Income, Women's Income Control, Prices}). \quad (7)$$

Explanation of individual children's nutritional status in terms of their weight-for-age and other related indicators (NUTSTAT) is attempted to trace the effects from changed income level and spending via consumption to nutritional outcome. Food consumption as explained in (7) above is thus related to the nutritional situation given the household's health environment (see also Figure 2):

$$\text{NUTSTAT} = f(\text{Child Demographics, Household Demographics, Food Energy Consumption, Health Environment}). \quad (8)$$

The specifics of these models are discussed in the respective chapters of the report.

5

PRODUCTION AND INCOME EFFECTS OF THE COMMERCIALIZATION PROCESS

In this chapter, household subsistence orientation is quantified and discussed along the lines of the three alternative concepts described in Chapter 4. Then the agricultural production system is described, especially the use of labor, and the determinants of productivity of land and labor in the subsistence and commercialization subsectors of agriculture. The next section then focuses on off-farm work and employment in nonagriculture sectors, as these growing sources of employment are contributing much to commercialization of the rural economy. A description of the sampling and data collection that form the basis of these analyses is in Appendix 1.

Household Subsistence Orientation: Concepts and Basic Patterns

Average farm size in the study area is 0.74 hectare; it is 0.64 hectare if the land in the Gishwati forest is excluded (Table 6). The bottom 25 percent (lowest quartile) of farms have an average of only 0.23 hectare of land. The smallest farms have absolutely and relatively less land in Gishwati and support smaller households (3.9 persons versus the sample average of 5.1), and their household heads are younger (36.7 years versus the average of 42.5). The younger age of farmers in the lowest quartile is probably found because those farms resulted from land fragmentation during recent inheritances.

The three alternative concepts discussed in Chapter 4, assessing household subsistence orientation, are presented with their quantitative results in Table 7. Agriculture in the study area is still considerably subsistence-oriented. According to concept 1—which expresses the value of subsistence production as a percent of total agricultural production—69.2 percent of agricultural production is for home consumption. Also, taking the broader approach of concept 2—which relates the value of subsistence production to total

Table 6—Household size and landholdings, and age of household head, 1985/86

Farm-Size Group	Farm-Size Average: Total Land	Farm-Size Average: Land in Gishwati Forest	Average Persons per Household	Average Age of Household Head
	(hectares)			(years)
Bottom quartile	0.23	0.03	3.9	36.7
Second quartile	0.45	0.04	5.1	39.8
Third quartile	0.75	0.06	5.6	45.3
Top quartile	1.53	0.29	5.9	48.1
Average	0.74	0.10	5.1	42.5

Source: *International Food Policy Research Institute survey, 1985/86.*

Table 7—Alternative concepts assessing household subsistence orientation, by person-land ratio and total expenditure quartiles, 1985/86

Group	Concept 1	Concept 2	Concept 3
	Value of Subsistence Production		
	In Percent of Total Agricultural Production Value	In Percent of Total Income	Value of Consumption from Own Production in Percent of Total Value of Consumption of Foods and Nonfoods
Person-land ratio quartiles (averages in persons/hectare)			
Bottom quartile (21.3)	77.4	30.1	41.1
Second quartile (11.5)	66.5	37.4	47.2
Third quartile (7.4)	69.4	38.6	52.2
Top quartile (4.1)	68.4	39.0	49.9
Total expenditure quartiles[a] (averages in FRw)			
Bottom quartile (6,303)	67.1	41.5	50.0
Second quartile (8,692)	74.8	52.4	50.0
Third quartile (11,698)	72.5	44.7	52.0
Top quartile (19,037)	57.2	22.6	43.5
Total average	69.2	36.9	47.8

Source: International Food Policy Research Institute survey, 1985/86.

[a]Annual expenditure per capita, including the value of food consumed from own production (this may be viewed as an income proxy).

income, including off-farm and nonagricultural income and transfers—it was found that subsistence food production represents a high share (about 36.9 percent) of total income. Likewise, according to the consumption-oriented concept 3—which relates the value of consumption from own-production to the total value of consumption of foods and nonfoods—47.8 percent of total consumption values are from own production.

Concepts 2 and 3 should, in principle, give similar values of subsistence orientation if there were no savings and dissavings,[6] and if producer prices of food were equal to consumer prices.[7] Of course, these are strong assumptions, and considerable differences between the two concepts can be expected. It was found that especially in the bottom and top expenditure quartiles, the difference between the two concepts widens, while in the two middle quartiles the two concepts are quite consistent (Table 7). Usually consumption and expenditure survey data are more trustworthy than income surveys. If this may also be assumed here, two factors could be at play explaining the different results: one, that agricultural subsistence income is underestimated or total income overestimated in concept 2, thereby decreasing the subsistence percentage; and two, that savings may play a substantial role, at least at the top of the income distribution, thereby resulting in the different outcomes in the two concepts. While the first factor would reflect a data quality

[6]Minor deviations can be expected, as the period of the consumption survey (1986) is not identical with that of the income survey (1985/86).

[7]In concept 2 (income concept), producers' selling prices are applied to value the nonmarketed food production.

problem, the second would be a legitimate reason for an expected deviation between the figures in the two concepts. A definite answer is not possible.

A striking result of this assessment of household-subsistence orientation from various angles is the weak relationship of subsistence orientation, both with land endowment (person-land-ratio) and with household income level, as represented by total expenditure. It is only in the top quartile that a clear reduction in the relative importance of subsistence shows up (bottom of Table 7, concepts 2 and 3). Behind this, however, is a higher absolute value of subsistence production in the top income groups.

Also quite striking is the result depicted by concept 1—that agricultural market integration does not increase significantly with increased land endowment in the range of this sample. The most land-scarce group, with an average of 21.3 persons per hectare, retained 77.4 percent of their production in value terms, and the group with the lowest person-land ratio retained 68.4 percent. The aggregate marketed surplus is, on average, 31.6 percent from sorghum beer, 31.5 percent from Gishwati potatoes (in 1986), and the rest from other crops and livestock. Sorghum beer sales are particularly important for the most land-scarce households (61.8 percent of sales value; see Table 8, column 2), while potatoes in Gishwati are more important for the land-rich households.

Although subsistence orientation is high, on average, the degree of agricultural subsistence orientation (concept 1) varies a great deal between households. Ranking households by that degree shows that the top quartile (that is, the most subsistence-oriented and least market-integrated) sells only goods equivalent to 4.2 percent of the total value of production, while the bottom quartile sells 57.8 percent. The share of land in Gishwati correlates positively with increased commercialization (Table 9, rows 2 and 3).

This is a rural economy with much part-time farming. More than half of the income is earned off-farm (Table 10, column 3). No clear-cut relationship between total income and degree of agricultural subsistence orientation is visible from the simple tabulation (Table 9, last row).

In Table 10, households are ranked by the relative importance of subsistence production over total income—that is, according to subsistence concept 2. If households are ranked according to this more comprehensive subsistence concept, the households

Table 8—Farm size, subsistence orientation in agricultural production (concept 1), and main sources of market integration, 1985/86

Person-Land-Ratio Group	Value of Subsistence in Percent of Total Agricultural Production Value (Concept 1)	Value of Sorghum Beer Sales in Percent of All Sales of Farm Produce	Value of Gishwati Potato Sales in Percent of All Sales of Farm Produce
Bottom quartile (land poorest)	77.4	61.8	15.2
Second quartile	69.4	45.5	11.4
Third quartile	66.5	29.7	25.0
Top quartile (land richest)	68.4	15.5	53.9
Average	69.2	31.6	31.5

Source: International Food Policy Research Institute survey, 1985/86.

Table 9—Subsistence orientation of agriculture (concept 1) and income sources, 1985/86

Item	Subsistence Orientation in Agricultural Production (Concept 1)				
	Bottom Quartile (Least Subsistence-Oriented)	Second Quartile	Third Quartile	Top Quartile (Most Subsistence-Oriented)	Average
	(average value of sample)				
Value of sales in percent of agricultural production value	57.80	29.90	15.00	4.20	32.50
Total farm size (hectares)	0.87	0.79	0.56	0.72	0.74
Land in Gishwati (hectares)	0.17	0.07	0.08	0.06	0.10
Value of subsistence production per capita (average = 100)	87	92	94	127	100
Value of total income per capita (average = 100)	110	118	76	95	100

Source: International Food Policy Research Institute survey, 1985/86.

Table 10—Subsistence orientation (concept 2) and income from other sources, 1985/86

Group by Degree of Subsistence over Total Income[a] (Concept 2)	Farm Size	Total Income per Capita (Average=100)	Off-farm Income per Capita	Wage Income per Capita
	(hectares)	(average value of sample)	(percent of total income)	
Bottom quartile (least subsistence-oriented)	0.75	172.0	80.1	50.9
Second quartile	0.61	92.7	46.6	38.5
Third quartile	0.74	82.3	32.6	26.5
Top quartile (most subsistence-oriented)	0.86	54.1	15.4	8.9
Average	0.74	100.0	57.5	39.3

Source: International Food Policy Research Institute survey, 1985/86.
[a]Total income includes off-farm income, transfers, and remittances.

with the highest degree of subsistence orientation turn out to be the poorest in income terms (Table 10, column 2). It is also interesting to note that the off-farm income share is highest (80.1 percent) in those households that have very little subsistence production, and these households also have the highest share of wage earnings (Table 10, columns 3 and 4).

Although farm size does not show a consistent variation in the above tabulations along classes of subsistence and commercialization, the land base of households is, of course, a major factor that determines households' income earning at this location. Grouping farms in quartiles by farm size shows that the top 25 percent (with an average 1.53 hectares) has farms 6.7 times larger than the bottom quartile (0.23 hectare); on a land-per-capita basis, the top quartile has 4.4 times more land per person than the bottom quartile. Farm income per capita in the top quartile, however, is "only" 1.7 times higher than that in the bottom quartile (Table 11, column 2). This suggests that the smaller farms make up for a large proportion of the difference in size by higher land productivity. This will be further explored in the following section and plays a key role in the long-term simulations discussed in Chapter 8.

A surprising result of this assessment is that per capita off-farm income rises at least as much as does farm income with increased farm size. Therefore, the share of total off-farm income for the larger farms is roughly the same as for the small farms (Table 11, column 5). Wage incomes, however, decrease with rising farm size.

An important research undertaking is to identify the measures that farmers take to increase returns to land (and labor) on their increasingly limited land base as well as the role that new crop technology plays in this context. For this purpose, a detailed descriptive and analytical account of the production system and of determinants of productivity in agriculture follows. Also, the important nonagricultural income sources that largely determine the degree of commercialization at the location need to be better understood in order to identify ways to induce the expansion of productive employment in the nonfarm sectors. This is approached in a later section.

The Agricultural Production System

This section makes extensive use of the detailed farm- and plot- specific information, including yield and labor data, that were collected for a subsample of 20 percent of the main sample. For internal consistency, most of the information in this section refers to this subsample only. The subsample households are somewhat less land-short than the main sample. Farm size is 0.86 hectare as compared with 0.74 hectare in the main sample.

Table 11—Income by farm-size group, 1986

Farm-Size Group	Farm Size (Average of Group)	Farm Income per Capita (Average=100)	Total Income per Capita (Average=100)	Share of Income from: Agriculture[a]	Share of Income from: Total Off-Farm Income
	(hectares)	(average value of sample)		(percent of total income)	
Bottom quartile	0.23	76.6	71.5	46.8	53.2
Second quartile	0.45	91.2	96.4	40.9	59.1
Third quartile	0.75	104.8	85.4	56.1	43.9
Top quartile	1.53	127.0	146.5	35.7	64.3
Average	0.74	100.0	100.0	42.5	57.5

Source: International Food Policy Research Institute survey, 1985/86.

Note: The data in this table cover only January-October, 1986.

[a]Including income from sorghum beer.

The farming systems prevailing in the study area are exclusively based on smallholder agriculture, with family labor providing the bulk of total labor inputs. Table 12 summarizes the subsample family size, total farm size, and origin of farmland by different modes of acquisition. In the table, two different farming systems are distinguished according to altitude—below 2,280 meters for the first group, and above 2,280 meters for the second. The lower-altitude systems are more sorghum/sweet potato/beans-oriented, while the higher-altitude systems are more maize/peas-oriented (Table 13). The person-land ratio, expressed in adult-equivalent persons per hectare, is significantly higher for the lower-altitude group (Table 12).

Looking at the different modes of land acquisition, Table 12 reveals that, on average, 62 percent or 0.53 hectare of the total area is owned (that is, inherited or bought), 17 percent is rented for cash, and 11 percent is obtained without payment, mostly through the extended family.

The main reason for the larger proportion of Gishwati land in the higher-altitude group is that those households directly border on the Gishwati forest and thus have easier access to Gishwati fields.

According to the climatic conditions of the study area—mainly the bimodal pattern of rainfall distribution—two agricultural seasons are to be distinguished: the first season starts with the onset of the rains in mid-September and ends in late February or early March, while the second season covers the rest of the year.

The agricultural production systems of the study area are almost entirely based on food-crop production. Land use is dominated by the main cereals. On average, maize (30 percent or 0.26 hectare) and sorghum (17 percent or 0.15 hectare), both in sole stands and under mixed cropping, account for almost half the total farm size, followed by sweet potatoes and peas with approximately 15 percent (or 0.13 hectare) each, the remainder being beans and wheat and other crops of minor importance (Table 13). Cultivation of potatoes outside the Gishwati area is of only little importance.

Farmers practice both mixed cropping and sole-stand cropping for the main cereals and beans, but the system of mixed cropping is preferred. The agricultural production technology is almost exclusively based on manual labor, with the hoe and machete being the most important and sometimes the only agricultural tools. The only exception to this is the employment of knapsack sprayers to treat potatoes against late blight, but such spraying is limited to the cultivation of potatoes in the Gishwati area. Apart from that, no pesticides are used in food crop production.

So far, the application of mineral fertilizers is mainly found in agricultural development projects and tea plantations. A program of fertilizer distribution to progressive, successful farmers during 1984-87 reached out to only a few producers in the study area.

Although improved varieties exist for some crops like peas, beans, and wheat, at present their use is not very widespread. Potatoes are the only exception. There is a considerable range of improved potato seeds, selected and distributed by PNAP in particular, and farmers make more widespread use of them. No improved varieties of maize and sorghum are available so far for the higher-altitude regions of Rwanda.

At the end of 1985, animals were kept in 79 percent of all sample households. The average number of cattle was 0.6 in households that kept any animals, but only 37 out of 190 farms kept cattle. There is a high degree of variation within the sample—45 out of a total of 84 cattle (or 54 percent) were owned by only 3 households. Goats were kept by 115 (or 61 percent) of all sample households; sheep were kept by 88 households (or 46

Table 12—Farm size, source of land acquisition, and labor-land relationships in subsample households, 1986

Item	All Subsample Farm Households		Lower-Altitude Group (N=21)		Higher-Altitude Group (N=21)	
	Average	C.V.[a]	Average	C.V.[a]	Average	C.V.[a]
Farm size and land acquisition						
Farm size without land in Gishwati (hectares)	0.86	0.68	0.74	0.59	0.98	0.70
Farm size with land in Gishwati (hectares)	0.75	0.60	0.70	0.61	0.79	0.60
of which percent[b] - inherited	42.2	0.76	36.6	0.84	47.6	0.70
- bought	20.3	1.25	26.0	`1.14	14.6	1.33
- cash rental	16.6	0.95	18.2	0.93	15.0	0.97
- obtained free[c]	10.9	2.10	14.4	1.97	7.3	2.19
- rented out	1.3	3.31	0.7	4.51	2.0	2.58
- Gishwati	8.7	1.49	4.1	2.73	13.5	1.00*
Average number of plots[b]	10.8	0.36	11.5	0.35	10.1	0.38
Average size per plot (square meters)[b]	806.0	0.56	621.0	0.40	991.0	0.58**
Labor-land relationships						
Family size (persons)	4.98	0.43	5.19	0.40	4.76	0.47
Person-equivalents[d]	2.67	0.47	2.63	0.46	2.71	0.49
Person-land ratio (person-equivalents per hectare, including Gishwati land)	3.95	0.52	4.70	0.51	3.27	0.46*
Person-land ratio (person-equivalents per hectare, excluding Gishwati land)	4.48	0.51	5.10	0.53	3.93	0.43

Source: International Food Policy Research Institute survey subsample, 1986.

[a]C.V. = coefficient of variation.

[b]Derived from total farm size, including land in Gishwati.

[c]Land obtained for use without payment, mostly through family links.

[d]For definition, see Appendix 2, Table 56.

*Significant at the 0.05 level.

**Significant at the 0.01 level.

Table 13—Land allocation of subsample households, 1986

Crop	All Subsample Farm Households		Lower-Altitude Group (N=21)		Higher-Altitude Group (N=21)	
	Average	C.V.[a]	Average	C.V.[a]	Average	C.V.[a]
	(percent)[b]		(percent)[b]		(percent)[b]	
Maize (mixed cropped)	19.1	0.97	11.3	0.97	27.0	0.79**
Sorghum (mixed and sole stands)	16.8	2.18	22.9	1.82	10.6	2.97*
Sweet potatoes	15.5	0.86	22.9	0.55	8.1	1.19**
Peas	15.4	1.16	8.5	1.58	22.4	0.85**
Maize (sole stands)	10.9	1.25	10.8	1.24	11.1	1.29
Beans (mixed and sole stands)	6.3	2.29	10.0	1.94	2.7	2.35*
Wheat	2.0	3.05	0.8	2.20	3.2	2.66
Tobacco	0.1	7.00	0.1	5.00	0.2	4.74
Other (such as vegetables, fuelwood, and potatoes outside Gishwati area)	3.0	...	4.0	...	2.0	...

Source: International Food Policy Research Institute survey subsample, 1986.

[a]C.V. = coefficient of variation.

[b]Derived from total farm size without land in Gishwati.

*Significant at the 0.05 level.

**Significant at the 0.01 level.

percent). Except for poultry, where an average of 3.4 chickens were kept by 22 percent of all sample households, the importance of any other domestic animals is very limited. In terms of tropical livestock units (TLU, as defined in Jahnke 1982, 10), the respective figures are 0.81 TLU per household for the whole sample and 1.02 TLU for those who kept animals. For the latter, this corresponds to 1.41 TLU per hectare of farmland, which is rather high compared with livestock densities found in other regions of tropical highlands in Africa.

The number of TLU per household is positively correlated with total farm size (0.55). The number of cattle is significantly higher for the higher-altitude group, and to a lesser extent the number of goats, too. It has to be kept in mind that the higher-altitude parts of the study area directly border on the Gishwati forest and that a substantial number of cattle are kept in cooperatives of the Gishwati GBK project, thus not depending on the supply of fodder from farmland outside the Gishwati area.

Labor Use and Division of Labor in Agriculture

Labor Time Allocation

On average, the total labor input for agricultural field work was 198 person-days per household per year (September 1985 to August 1986). Family labor provided an average of 73.9 percent to the total labor input, while the share of nonfamily labor averaged 26.1 percent. While the agricultural labor input per adult family member (that is, household members of 15 years of age and above) was found to be rather low and averaged 63 person-days per year, the average total labor time per adult family member amounted to 154 person-days (Table 14). The difference is due to the time spent on the reciprocal

Table 14—Average labor time allocation in person-days per adult family member, 1985/86

Labor Allocation	Adult Family Member[a] Days	Percent of Total	C.V.[b]
Agricultural labor on own farm	63	40.9	0.35
Reciprocal agricultural labor exchange with others	15	9.7	0.70
Off-farm labor	30	19.5	1.25
Other activities[c]	46	29.9	0.59
Total	154	100.0	...

Source: International Food Policy Research Institute survey subsample, 1985/86.

[a]Weighting family members above 55 years of age by 0.6.

[b]C.V. = coefficient of variation.

[c]These include, among others, construction, repair and maintenance of houses, stores and stables, rural handicrafts, anti-erosion activities, sorghum beer production, and some social activities.

exchange of agricultural labor with other households, on off-farm work, and on other activities not directly related to agricultural production.

According to the agricultural seasons and the respective cropping patterns, the average monthly labor input for agricultural activities follows a distinct seasonality, with the most important labor peak occurring in September, when the average labor input was 33 person-days per household. The main activities recorded for this month were the weeding of maize and sorghum, and soil preparation for and planting of peas and beans. A second peak occurred during the months of May and June (25 and 20 person-days, respectively), a period almost exclusively dedicated to soil preparation for and planting of maize and sorghum. Another important peak found in November was due to high labor requirements for the second weeding of the main cereals as well as soil preparation for and planting of sweet potatoes.

The distinct seasonality of the total agricultural labor input per month is not leveled off by the employment of nonfamily labor. However, because the average family labor input for off-farm employment does not vary much between months, the coefficient of variation in the total family labor input for agricultural and off-farm activities is lower than it is for agricultural fieldwork alone.

Table 15 summarizes the allocation of the total labor input to different crops, the total labor input in person-days per hectare for the most important crops (and for leading crops in crop mixes), and the composition of the total labor input according to family and nonfamily labor. The total labor input is highest for potatoes, with 434 person-days per hectare, and is lowest for peas, with 142 person-days per hectare. The respective shares of family and nonfamily labor do not vary much for the different crops. The contribution of family labor was found to be lowest in the case of sorghum (70 percent), followed by peas (71.8 percent) and maize (71.6 percent), while it was highest for cultivating beans (86.3 percent) and sweet potatoes (82.7 percent).

Women's Predominant Role in Agriculture

Men contributed on average 25.3 percent of total family labor input in agriculture (19 percent for the household head and 6.3 percent for male adults above 15 years of age).

Table 15—Allocation of total labor input by crop and by family and nonfamily labor, 1985/86

Crop	Percent of Total Labor Input	Total Labor Input per Hectare	Percent of Family Labor	Percent of Nonfamily Labor
		(person-days)		
Maize	21.2	306	71.6	28.4
Sorghum	18.1	404	70.0	30.0
Potatoes	19.5	434	77.0	23.0
Sweet potatoes	15.2	398	82.7	17.3
Peas	7.2	142	71.8	28.2
Beans	5.9	400	86.3	13.7
Other crops	12.9	n.a.	n.a.	n.a.
Total	100.0	...	...	...

Source: International Food Policy Research Institute survey subsample, 1985/86.

Notes: n.a. means not applicable. Labor allocation to crops in mixed cultivation was identified in the plot-specific surveys by taking account of the share of the respective crop in the plot's output as far as activities applicable to the joint crops are concerned (for example, weeding).

While the wife of the household head provided 68.6 percent, women's total share amounted to a total of 74.1 percent when adult daughters were included. The contribution of both male and female children below 15 years of age did not exceed 0.6 percent on the average (Table 16).

For all crops and activities, the share of women's labor is higher than it is for men. Men's participation is important for soil preparation and harvest activities, while planting and weeding are predominantly tasks of women. The only exception to this is in potatoes and, to a lesser extent, sorghum, where men contribute considerably to the family labor input for planting and weeding activities. In the case of weeding for potatoes, this is mainly the application of fungicides to control late blight, which is almost exclusively done by men, but women join to transport water to the fields. It is interesting to note that new technology in potatoes brings in more male labo and thus makes it more a "men's crop."

About 78.2 percent of all nonfamily person-days was provided by the reciprocal exchange of labor with relatives or neighbors or both, 17.8 percent was wage labor paid in cash, 2.1 percent was wage labor with payment in kind, and only 1.9 percent was in the form of nonreciprocal exchange of labor (Table 17).

Differences exist by crop, activity, and type of nonfamily labor. The employment of nonfamily labor is activity-specific and, except for peas and beans, is concentrated on soil preparation, ranging from 40.3 percent of all nonfamily labor for cultivation in maize to 49.6 percent in the case of sweet potatoes. A substantial contribution of cash labor was found for preparing soil for maize, sorghum, and potatoes, and for weeding and harvesting potatoes. The reciprocal exchange of labor is most important during planting and harvesting of crops.

Land Shortage and Labor Use in Agriculture

Both family and total labor input per hectare were substantially higher for the smallest farm-size group than for the largest (Table 18). The share of men in total family

Table 16—Distribution of family labor input by sex and age groups and by activities for different crops, 1985/86

Crop/Activity	Share of Total Family Labor Input	Share of Total Family Labor Input		
		Men	Women	Children[a]
		(percent)		
Maize				
Cultivating	30.1	39.0	61.0	0.0
Planting	12.5	5.5	93.7	0.8
Weeding	40.2	1.6	97.8	0.6
Harvesting	17.0	34.2	65.0	0.8
Other	0.2	0.0	100.0	0.0
Total	100.0	...	...	...
Sorghum				
Cultivating	34.0	45.8	54.2	0.0
Planting	13.7	26.5	72.2	1.3
Weeding	36.5	2.9	96.2	0.9
Harvesting	15.2	40.2	58.7	1.1
Other	0.6	0.0	100.0	0.0
Total	100.0	...	...	...
Potatoes				
Cultivating	31.2	45.4	53.5	1.1
Planting	16.4	37.2	62.7	0.1
Weeding	25.7	41.3	58.4	0.3
Harvesting	26.7	40.4	59.3	0.3
Other	0.0	0.0	0.0	0.0
Total	100.0	...	...	...
Sweet potatoes				
Cultivating	39.1	35.0	65.0	0.0
Planting	27.9	4.1	95.8	0.1
Weeding	32.8	0.7	98.7	0.4
Other	0.2	0.0	100.0	0.0
Total	100.0	...	...	...
Peas and beans				
Cultivating	20.5	29.1	70.1	0.8
Planting	5.7	0.0	100.0	0.0
Weeding	13.6	0.0	99.7	0.3
Harvesting	31.4	33.8	65.0	1.2
Other	28.8	42.2	57.3	0.5
Total	100.0	...	...	...
Total family labor	100.0	25.3	74.1	0.6

Source: International Food Policy Research Institute survey subsample, 1985/86.

Note: Labor allocation to crops in mixed cultivation was identified in the plot-specific surveys by taking account of the share of the respective crop in the plot's output as far as activities applicable to the joint crops are concerned (for example, weeding).

[a]Both male and female below 15 years of age.

labor input was lower for the smallest farm-size group (22 versus 29 percent). When taking the share of the wife of the household head instead of all female family members above 15 years of age, the differences between both groups were even more pronounced, with the wife of the household head providing 74 percent of the total family labor in the smallest farm-size group, against 63 percent in the largest. This pattern of a decreasing women's share in agricultural family labor with rising farm size is found in many

Table 17—Distribution of total nonfamily labor input and type of nonfamily labor, by activities for different crops, 1985/86

Crop/Activity	Share of Total Nonfamily Labor Input	Type of Nonfamily Labor as Share of Total Labor Input: Cash	In Kind	Reciprocal Exchange	Nonreciprocal Exchange
	(percent)				
Maize					
Cultivating	40.3	58.1	2.5	37.5	1.9
Planting	13.3	17.0	0.0	81.1	1.9
Weeding	23.9	21.1	6.3	64.2	8.4
Harvesting	22.5	0.0	0.0	96.6	3.4
Other	0.0	0.0	0.0	0.0	0.0
Total	100.0	...	...	...	...
Sorghum					
Cultivating	45.4	45.7	0.0	53.8	0.5
Planting	10.7	14.9	0.0	85.1	0.0
Weeding	21.4	12.8	14.9	69.1	3.2
Harvesting	21.8	0.0	0.0	100.0	0.0
Other	0.7	0.0	0.0	100.0	0.0
Total	100.0	...	...	...	...
Potatoes					
Cultivating	43.6	68.6	3.2	28.2	0.0
Planting	8.2	2.9	0.0	97.1	0.0
Weeding	12.5	25.9	0.0	68.5	5.6
Harvesting	35.7	31.2	0.0	67.5	1.3
Other	0.0	0.0	0.0	0.0	0.0
Total	100.0	...	...	...	...
Sweet potatoes					
Cultivating	49.6	17.4	3.6	76.1	2.9
Planting	18.3	0.0	0.0	100.0	0.0
Weeding	32.1	0.0	3.4	96.6	0.0
Other	0.0	0.0	0.0	0.0	0.0
Total	100.0	...	...	...	...
Peas and beans					
Cultivating	10.9	20.7	6.9	72.4	0.0
Planting	0.9	0.0	0.0	100.0	0.0
Weeding	4.9	7.7	0.0	92.3	0.0
Harvesting	50.8	0.0	0.0	100.0	0.0
Other	32.5	27.9	2.3	69.8	0.0
Total	100.0	...	...	...	...
Total nonfamily labor	100.0	17.8	2.1	78.2	1.9

Source: International Food Policy Research Institute survey subsample, 1985/86.

developing countries. However, in this case, the relative decrease goes along with an absolute increase in women's agricultural work: the wife of the household head spent 87.6 days in the smallest versus 112 days in the largest farm-size group.

Productivity in Agriculture

Farmers in this study, like subsistence-oriented farmers anywhere else, are exposed to a risky production and market environment, and thus consider numerous factors when deciding what to grow and what not to grow. A quantitative assessment of these

Table 18—Family and total labor input for different crops and farm-size quartiles, 1985/86

Crop	Bottom Quartile		Top Quartile	
	Family Labor	Total Labor	Family Labor	Total Labor
		(person-days/hectare)		
Maize	308*	377*	153	220
Sorghum	321	426	242	347
Potatoes	511*	624*	174	264
Sweet potatoes	376	407	311	413
Peas	90	104	107	133
Beans	434	515	284	318
Total average per hectare	274	342	131	213

Source: International Food Policy Research Institute survey subsample, 1985/86.

Notes: Data are derived from total farm size, including Gishwati land.

*Significant at the 0.10 level.

determinants in the context of productivity computations at the farm level for the various crops is complicated by numerous factors in this specific case. Among these are the difficulty of quantifying inputs and outputs, field measurements, and the multitude of crop combinations in mixed cropping systems. These technical factors are one aspect of the problem. Another relates to the integration of subsistence production with production for the market and the important role of nonagricultural income earnings. This complex decisionmaking process is influenced not only by short-term profit maximization objectives in crop production, but also by the expectations regarding crop and labor markets and related risks that largely determine household-level food security.

Why They Grow What They Grow

Male and female members of the farm families in the survey were asked a set of questions concerning their reasons for growing or not growing the major crops generally found in the area. This survey of the stated reasons covers the production year 1985/86. The set of reasons given as options was a result of extensive survey pretesting. For eight major crops, farmers who were actually growing a particular crop were asked to indicate on a scale of 1 (very important) to 3 (not important) why they grew it (Table 19). Similarly, farmers who did not grow the crop were asked to indicate by the same scale of importance their reasons for not growing it.

Top priority for all food crops is indicated by the answer "We want to consume it, that's why we grow it." An exception is potato production in the Gishwati fields, which shows a mix of "grown for cash" and "grown for consumption." Labor considerations are of major importance for sweet potatoes and peas. Technical reasons are of substantial importance for growing or not growing a crop, as indicated by the values close to or below 2.0 in the respective second questions of Table 19—"fits (or does not fit) well to our fields."

Tea and tobacco are grown because of the desire to sell for cash. Similarly, those who choose not to grow them do so because they consider these crops either as "not selling well," in the case of tea, or requiring a substantial amount of labor in relation to the potential returns per labor input. In the case of potatoes grown in Gishwati fields, farmers who

Table 19—Stated reasons for growing or not growing a particular crop, 1985/86

Stated Reason	Potatoes	Gishwati Potatoes	Sweet Potatoes	Maize	Sorghum	Beans	Peas	Tea	Tobacco
	(value of indication)[a]								
Reasons for growing the crop (farmers who grew it in 1985/86)									
1. We want to eat/consume it	1.0	1.7	1.0	1.0	1.1	1.0	1.0	...	2.6
2. Fits well to our fields	2.1	1.8	2.0	2.1	2.0	2.3	2.1	2.3	2.1
3. We want to sell it for cash	2.7	1.5	2.5	2.7	2.2	2.8	2.6	1.2	1.1
4. The crop stores well	2.4	2.6	2.9	2.3	2.1	2.4	2.4	2.6	2.5
5. It is our custom to grow it	2.0	2.6	2.0	2.0	2.0	2.1	2.0	2.5	2.3
6. The crop always works out well; it is not risky	2.2	2.0	2.2	2.3	2.4	2.7	2.2	2.3	2.3
7. Does not cost much to grow	2.4	2.8	2.3	2.6	2.6	2.5	2.2	2.5	2.6
8. Does not require much work	2.4	2.9	1.9	2.7	2.9	2.5	1.9	2.9	3.0
(Number of observations)	(146)	(85)	(155)	(188)	(146)	(185)	(117)	(36)	(22)
Reasons for not growing the crop (farmers who did not grow it in 1985/86)									
1. We do not want to consume it	3.0	3.0	3.0	[b]	3.0	[b]	2.8	...	2.5
2. Our fields are not good for the crop	2.0	2.9	1.9	...	1.9	...	2.2	2.4	2.4
3. Does not sell well	3.0	2.9	2.8	...	3.0	...	2.9	2.2	3.0
4. Does not store well	3.0	3.0	2.4	...	2.9	...	3.0	2.9	2.9
5. We customarily do not grow it	2.7	2.5	2.3	...	2.4	...	2.5	2.5	2.4
6. There are frequent troubles with the crop	2.3	2.7	2.8	...	2.5	...	2.6	2.7	2.9
7. Costs too much to grow	2.6	2.3	3.0	...	2.9	...	2.7	2.3	2.5
8. Requires a lot of work	2.9	2.1	3.0	...	2.9	...	2.8	1.8	2.0
(Number of observations)	(43)	(21)[c]	(34)	[b]	(43)	[b]	(69)	(147)	(164)

Source: International Food Policy Research Institute survey, 1985/86.

[a]The mean values of indication are 1, very important; 2, important; 3, not important.

[b]Less than five observations.

[c]Only farmers who had access to a Gishwati field are included.

do not grow potatoes there mentioned as their second most important reason the high production costs. This is in line with the finding that the smallest farmers and lower-income farmers do not join in the Gishwati potato production to the same extent as larger farmers, who are less constrained by cash for input financing.

The risks that pertain to certain crops—especially potatoes—are considered by a number of farmers to be an important reason for not growing them, but riskiness or nonriskiness of crops does not show up as very important in the average figures presented in Table 19. Specific farm conditions are of major importance for production efficiency, and crop risks rank high among those at the specific production location, yet this concern is leveled out in the average figures presented. The impact of perceived risk on the degree of subsistence will be further discussed in the context of a multivariate regression analysis in Chapter 6.

In the next section, detailed farm- and crop-specific information is provided for the assessment of returns to land and labor by major subsistence crops. Following that, the more aggregate picture of labor productivity in this complex farming system is addressed, making use of econometric analysis.

Productivity of Major Crops: Gross Margins

The cropping systems prevailing in the study area are extremely labor-intensive, at least when compared with other African countries where farmers grow the same crops. Table 20 summarizes, based on the subsample data, the total labor input per hectare and the land and labor productivities of the various cropping systems. It further shows the respective gross revenues and gross margins per unit of land and labor. Unfortunately, there are no comparable labor input data available for Rwandan smallholder agriculture based on survey information for this zone.

By far the highest labor input was found for the cultivation of potatoes in the Gishwati area, with 622 person-days per hectare and season. From the sample data, it was impossible to exclude the amount of labor necessary for clearing the former forest vegetation when farmers cultivated potatoes for the first time, so the total amount of 622 person-days may be somewhat overestimated.

The total labor input for other food crops varies considerably—261 person-days for maïze in sole stands and under mixed cropping, approximately 400 person-days for sweet potatoes, but only 102 person-days for peas, which are grown with a traditional cropping technique that requires no deep soil preparation or weeding. The coefficients of variation indicate that, within the various cropping systems, labor input and yields do not vary substantially. It should be noted that the different crops considered in Table 20 are on the field for different lengths of time.

Food-energy production per unit of land, measured in calories[8] per hectare, is highest for potatoes and sweet potatoes, with approximately 5.5 million calories each, followed by maize and sorghum under mixed cropping and maize in sole stands. However, when comparing the relatively low energy output of beans and peas in particular, it has to be kept in mind that both crops (and potatoes, too) can be cultivated twice a year, while only one crop per year is possible for maize and sorghum.

In terms of gross margins per hectare, potatoes rank first with FRw 37,688 (US$419), followed by sweet potatoes and beans with approximately FRw 25,000 (US$280) each.

[8]All calories referred to in this report are kilocalories.

Table 20—Average land and labor productivity of different cropping systems, subsample households, 1985/86

Item	Maize (Sole Stands)	Maize (Mixed Stands)[a]	Sorghum (Mixed Stands)	Beans (Sole Stands)	Peas (Sole Stands)	Sweet Potatoes (Sole Stands)	Potatoes (Sole Stands)	Tea (Small-holder)[b]
Total labor input								
(person-days/hectare)[c]	261.6	260.5	346.9	315.1	101.5	398.0	621.8	470.0
	(0.42)	(0.38)	(0.64)	(0.24)	(0.56)	(0.63)	(0.78)	(0.40)
Yield (kilograms/hectare)[c]	1,037	...	...	874.6	476.1	5,055	9,615	2,692
	(0.45)			(0.50)	(0.55)	(0.42)	(0.87)	(0.49)
Yield (1,000 calories/hectare)	3,383	3,789	3,649	2,655	1,488	5,472	5,526	...
Gross revenues								
(FRw/hectare)	14,518	25,222	20,361	26,238	14,283	25,275	57,688	29,622
(US$/hectare)	161	281	226	292	159	281	642	329
Variable costs: (seeds; fungicides for potatoes only)								
(FRw/hectare)	625	11,375	6,775	1,500	1,500	0	20,000	8,805
(US$/hectare)	7	127	75	17	17	0	222	98
Gross margin								
(FRw/hectare)	13,893	13,847	13,586	24,738	12,783	25,275	37,688	20,817
(US$/hectare)	155	154	151	275	142	281	419	232
Labor productivity (calories/person-day)	12.9	14.6	10.5	8.4	14.7	13.7	8.9	...
Gross margin								
(FRw/person-day)	53.1	53.2	39.2	78.5	125.9	63.5	60.6	58.3
(US$/person-day)	0.62	0.59	0.44	0.87	1.40	0.71	0.67	0.65
Number of observations	21	24	19	18	35	6	18	12

Source: International Food Policy Research Institute survey subsample, 1985/86.

Note: US$1.00 = FRw 89.90 (1986 exchange rate; average for January-August).

[a]Most frequently maize, beans, and potatoes.

[b]Average for 1985/86 (annual).

[c]Figures in parentheses are coefficients of variation.

The gross margins per hectare are almost identical for both maize cropping systems and sorghum; peas rank last with FRw 12,783 (US$142) per hectare and season.

However, in terms of labor productivity, the ranking changes. Here, the food-energy production per person-day is highest for peas and maize under mixed cropping, with about 14.7 calories per person-day each, and sweet potatoes, with 13.7 calories; beans and potatoes rank lowest, while sorghum and maize (both in sole stands) are in the middle range.

Peas are by far the most profitable crop, with FRw 126 (US$1.40) per person-day, which is more than three times the labor productivity of sorghum in mixed stands and approximately twice as high as the returns to labor for sweet potatoes (FRw 63.5 per person-day, or US$0.71), potatoes (FRw 60.6), and tea (FRw 58.3). For both maize cropping systems, the returns to labor are almost the same, about FRw 53.0. Hardly any crop production reaches labor productivity levels close to the official minimum wage rate, which was FRw 100 per day during the survey period.

The highest variable production costs of FRw 20,000 per hectare and season occur for potato cultivation,[9] followed by maize in the mixed cropping system (FRw 11,375), tea (FRw 8,805), and sorghum (FRw 6,775). In the case of sweet potatoes, no variable costs appear because farmers usually provide their own planting material or get it free from neighbors or relatives. At least, no regular market of sweet potato stalks could be observed.

Aggregate Production Relationships

Production relationships in the agricultural system are fairly complex. The interactions between components of the system, especially the complementarity between factors of production—land, labor, and capital—and how they relate to aggregate output, could not be captured by the crop-specific analysis. Following the conceptual framework in Chapter 4, the aggregate production relationships are evaluated here. First, an aggregated all-crops production function of the Cobb-Douglas type is estimated and discussed—corresponding to equation (5) in Chapter 4—and, second, an attempt is made to explain differences in labor productivity in agriculture of the sample households in order to trace determinants and effects of agricultural change. These two production analyses are done here in parallel because of the inherent weaknesses of production function analyses based on cross-sectional information. Assessing relationships from two different angles at different levels of aggregation will help in determining ranges of basic relationships and determinants—that is, of labor productivity.

Generally, some caution should be used when interpreting the estimation results from Cobb-Douglas production functions of the nature presented here (see, for instance, Upton 1987 and Dillon 1977). First, the standard specification used involves absolute output in relation to a size variable. Second, some underlying variables may affect both input and output levels (for example, management skills). Also location-specific factors come into play in this context (a soil-quality variable is included in the model used here, as an attempt to capture this aspect). These weaknesses should be kept in mind when drawing conclusions from the analysis.

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[9]Based on information provided by the GBK project office and D. Haverkort of the *Centre international de la pomme de terre/Programme national pour l'amélioration de la pomme de terre* (CIP/PNAP) (1985).

Results of the Cobb-Douglas production function estimates are presented in Table 21. It should be noted that the labor and the capital variables are rough approximations of the actual labor input and capital for agricultural production only (see variable descriptions at the bottom of Table 21).[10] The results of the econometric estimation show the dominant role of land for total production in agriculture in this land-scarce environment. According to the model results, the production elasticity of land is 0.53—that is, a 10 percent increase in availability of land for a farm household increases total output, other things holding constant, by 5.3 percent.

The production elasticity of labor is 0.22. This low level is not surprising given the excess availability of labor and the shortage of land. More surprising is the fairly high production elasticity of capital at 0.19. Whether or not this indicates underinvestment in capital for agricultural production cannot be explored here. Average capital stock per farm for crop production was computed at FRw 1,181 (US$13.14).

In this context, it should be remembered that the introduction of capital inputs into a production function raises many problems because lag structures between use of capital inputs and output response are complex and capital investments may be lumpy or indivisible, so a smooth mathematical function provides only for a rough description of the response. Cautious interpretation is therefore called for. This general problem also translates into limitations of deriving scale effects from the Cobb-Douglas function estimate as is usually done. In principle, adding up the production elasticities of the three key factors of production (LAND, LABOR, CAPITAL) gives a rough indication of the

Table 21—Aggregate agricultural production function estimates

	Exogenous Variables[a]							
	LAND	LANDQ	LABOR	CAPITAL	Constant	R^2	F	Degrees of Freedom
Parameter	0.5257	-0.1911	0.2202	0.1917	7.560	0.506	48.9	183
t-value	(8.87)	(-2.18)	(2.14)	(3.19)				
Mean value of variable	-0.56	1.70	6.05	6.76	...	...	...	...
Standard deviation	0.71	0.41	0.40	0.68	...	...	...	...

Note: The dependent variable is AGPROD = logarithm of total value of 1985/86 agricultural production in FRw.

[a]Definitions of variables:

- LAND = logarithm of farm size in hectares.
- LANDQ = land-quality index; based on subjective evaluation by farmer on field-by-field basis (1=better than average, 2=average, 3=worse than average).
- LABOR = logarithm of total available adult labor force for agriculture in days/year (total number of persons above age 15 times days of cropping year minus days of off-farm work, days sick, days absent of individuals, plus hired labor days).
- CAPITAL = logarithm of present value of all tools and implements in FRw.

[10]It may be hypothesized that beyond labor, land and land quality, capital, and also human capital would impinge on farm output. In a different specification, tests were made for the effects of schooling (of household head or wife or both) and of caloric consumption per adult-equivalent (approximating food-energy sufficiency). Both variables were statistically not significant.

nature of economies of scale. This exercise suggests that, as the sum of the production elasticities is 0.93, thus slightly below one, there may be diseconomies of scale given the current production technology in the farming system. While at first glance this may be surprising, given the very small farm size in the area, the mountainous character of the area might indeed explain why larger farm sizes do not lead to reduced costs of production or higher returns per unit of factor input.

Average returns to labor show considerable variance in the overall sample. Table 22 shows a breakdown by three groups of households, arranged according to their level of labor productivity in agriculture, and also presents various household and farm characteristics of these groups in terms of average indicators. A high level of labor productivity found in the top tercile is associated with greater farm size per capita, as expected, better land quality, and a substantially higher use of production capital (monetary value of tools and implements). These joint variations of production factors may hint at potential problems of the Cobb-Douglas production function estimates already discussed in general terms above.

Households with higher labor productivity also have a higher sum of total annual food and nonfood consumption value, which may be viewed as an income proxy. The farm households with the high labor productivity in agriculture are thus richer. Yet, total expenditure per capita in the top productivity tercile is only 7 percent higher than the

Table 22—Labor productivity in agriculture, by farm and household characteristics, 1985/86

	Labor Productivity			
Characteristic	Bottom Tercile	Middle Tercile	Top Tercile	Average
Labor productivity (average) (total average = 100)[a]	35.0	78.6	182.9	100.0
Farmland per capita (hectares)	0.10	0.14	0.29	0.13
Land-quality index[b]	1.73	1.76	1.62	1.70
Monetary value of tools and implements (FRw)	882	1,163	1,483	1,181
Altitude of farm (meters)	2,306	2,316	2,345	2,322
School years of household head (average)	0.74	0.97	0.91	0.87
Total annual expenditure/capita (FRw)	10,732	11,306	12,225	11,432
Calories/adult-equivalent, May 1986	2,467	2,607	2,866	2,650
Subsistence consumption (percent of total expenditure)	46	48	52	48
Household size (persons)	5.20	5.60	5.90	5.60
Women of working age (percent of all persons of working age)	51	54	48	51
Children younger than five years (percent of household size)	25	27	34	29

Source: International Food Policy Research Institute survey, 1985/86.

[a]This figure is computed as follows on the basis of available working days for agricultural and home production: agricultural net income 1986/[(persons of working age in household - periods of sickness - family members' time in off-farm work) x working days over periods]. The average labor productivity for all sample farms computed this way over the year was FRw 26 per available working day in 1986.

[b]Better than average = 1; average = 2; worse than average = 3; based on subjective evaluation by farmers on field-by-field basis.

average (while agricultural labor productivity in that group is 83 percent above the average). The gap is closed primarily by off-farm income in households with the smallest farms. In line with the higher income in the top tercile is the finding that these households consume higher levels of food energy per adult-equivalent person. These households also obtain a somewhat higher share of their total consumption value out of own-produced food (52 percent versus 46 percent in the bottom tercile).

In the following, an attempt is made to explain differences in labor productivity in a multivariate analysis. The issue of interest is to explore population density-productivity links. A more rapid population growth, by inducing a greater replacement of equipment, could increase the rate of growth of output (Srinivasan 1988). Boserup (1981) argues that farm technology is influenced by population density in a positive way. In this model, it is hypothesized that labor productivity is determined by availability and quality of land, the capital stock per person, human capital (approximated by schooling of head of household), and the altitude of the farm. Moreover, it is hypothesized that the demographic composition of the household, especially the share of women in the work force, impinges on average labor productivity in agriculture. The detailed specification of the model and the estimation results are presented in Table 23.

Farm size (land) and land quality show a highly significant impact on labor productivity in the expected direction. All other variables show at best an influence of weak statistical significance. Under the current circumstances of increased population growth and little new technology available to farmers, the parameter estimates suggest that a reduction in farm size (at sample mean) by 1.0 percent will reduce labor

Table 23—Determinants of labor productivity in agriculture

Variable[a]	Parameter	t-Value	Mean Value of Variable	Coefficient of Variation
LAND	9.467	4.29	-0.56	0.71
CAPITALP	3.496	1.47	5.71	0.67
LANDQ	-7.162	-1.96	1.70	0.41
SCHOOL	-1.189	-0.80	0.87	1.04
ALTITUDE	9.80E-03	0.87	2,322.00	140.00
WSHARE	-4.209	-0.50	0.51	0.18
CHILDSH	14.294	1.77	0.29	0.20
Constant	1.895	0.95		
$\hat{R}^2$	.127			
F-value	4.88			
Degrees of freedom	180			

Note: The dependent variable is net returns per day of family labor available for agricultural and home goods production.

[a]Definitions of variables:

LAND = logarithm of farm size in hectares.
CAPITALP = logarithm of present value of all tools and implements in FRw per adult person.
LANDQ = land-quality index (area weighted, 1=best, 3=worst).
SCHOOL = years of schooling of head of household.
ALTITUDE = altitude of farm in meters.
WSHARE = share of women of working age in total number of persons of working age in the household.
CHILDSH = share of children under five years in total number of persons in the household.

productivity by 0.36 percent. This finding is consistent with the results presented at the outset of this chapter indicating that labor productivity declines less than proportionally as farm size decreases (Table 11), which is in line with Boserup 1981 and, more recently—with specific reference to Africa—with Binswanger and Pingali 1987. From this elasticity of 0.36 of labor productivity with respect to farm size, the following may be extrapolated: if reduction in farm size continues at the rate of current population growth (about 4.0 percent in the study area), new "exogenous" agricultural production technologies would "only" have to contribute an incremental 36.0 percent of this rate (that is, 1.4 percent a year) in order to at least maintain current levels of labor productivity in agriculture. Induced indigenous techniques toward increased labor productivity—"Boserup effects"—would cover the rest as holdings get smaller. This would include an increased labor input per hectare and changes in land-use patterns. As pointed out by Salehi-Isfahani (1988), these Boserup effects are a description of endogenous technology rather than of behavior.

Still, a rate of technological change shifting labor productivity by 1.4 percent a year (on top of the expected 2.6 percent indigenous effect) is quite high and requires major efforts in research and input supply policy. Thus, the induced indigenous technical progress without explicit policies for technical change would be too slow to maintain current levels of labor productivity and could thereby result in increased poverty and lack of entitlements to food for the poor. Also, it needs to be stressed that the relationship between labor productivity and person-land ratio in the context of fragmentation cannot, of course, be extrapolated for long into the future, and the stated quantitative results apply only to the range of size patterns in the sample. (This issue is taken up in more detail in the long-term simulations in Chapter 8.)

Lipton (1990) points out that the success of population-driven processes (such as increased effective demand for technology) that enhance poor people's entitlement to food may depend on how swiftly they complete the demographic transition to lower birthrates. Assistance in achieving a swift transition becomes of critical importance in Rwanda, which at the national level still shows population growth rates of about 3.4 percent a year in the late 1980s with no indication of fast decline.

Off-Farm Employment

Off-farm employment was identified above as a key factor in rural diversification and commercialization (Chapter 3). Although agriculture is the main employer in the study area, the cash economy is largely consigned to the off-farm labor market. Improved understanding of the rural labor market is essential for an employment-oriented development strategy. Rapid expansion of the off-farm employment opportunities along with yield-increasing technological change in agriculture are the prerequisites for assured entitlements to food for the poor in this densely populated region.

Off-farm work, however, is to a substantial extent closely linked to agricultural production. In fact, forward and backward linkages of the agricultural sector are not negligible either. As will be seen, new commercial agriculture in the case of tea, and rural infrastructure investments related to agricultural development programs in the area are employers of major importance.

Quite differently from agricultural production for the market and particularly from food production for subsistence, which largely employs a female work force, off-farm work is largely a man's affair. Female off-farm employment is significant only for the younger age groups; in fact, girls under 16 work more off-farm than boys of the same age group (Table 24). This changes, however, in the 16-24 age group, and above the age of 25, female off-farm employment is almost negligible. Men in the 25-54 age group work, on average, five to about eight days a month off-farm.

Dominant Role of Projects and Agroindustries

Off-farm employment of farm households fluctuates considerably within a year and over the years. Male off-farm employment in the 25-54 age group was down by 40 percent during the summer of 1986 compared with the earlier part of 1986 (Table 24). Month-to-month fluctuations of aggregate off-farm employment are also considerable and to a large extent are due to the seasonality of employment offered by the major local agroindustries and agricultural development programs in the region (Figure 5). The labor demand in the tea sector, for instance, peaks in April and August. This demand is of a fairly regular seasonal nature. The employment offered by the World Bank GBK scheme—the reforestation and livestock project in the Gishwati forest—represents another type of irregular labor demand. The scheme employed a work force of 7,000 at its peak in 1984 (February-May).[11] That employment was down to 3,500 in June-August 1986, and in September 1986 another 3,000 workers were laid off, bringing the work force to about 500. These changes are reflected in the sample households. The share of employment provided by that scheme dominated the off-farm employment in November 1985 but became negligible in August 1986 (Figure 5).

The central role of projects for employment is also reflected in the structure of employment in the rural labor market, as presented in Table 25: public development projects, such as the GBK scheme, the German IPV project, and the government road construction project, covered about one-third of total off-farm employment in 1985 but only one-fifth in 1986. Nearly 30 percent of off-farm employment in 1986 was generated by the tea factories in the area, which are, at least seasonally, substantial employers of the female labor force working off-farm. Children under 16 also work to a significant extent for these employers.

Paid daily agricultural work is of minor importance and only for households with a very limited land base (Table 26). The structure of off-farm work changes significantly with farm size. Employment in the tea factories is most important for the smaller farm

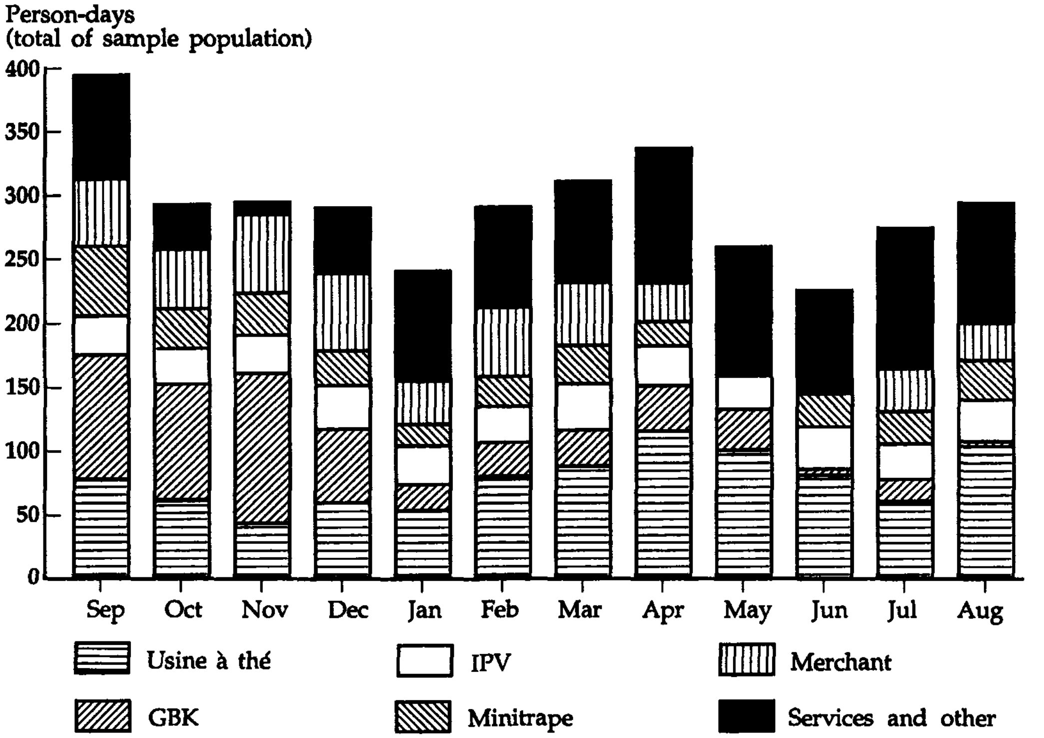
Table 24—Off-farm work by age and sex in different time periods, 1985/86

	Average Workdays per Month							
	11-15 Years		16-24 Years		25-54 Years		Above 54 Years	
Time Period	Male	Female	Male	Female	Male	Female	Male	Female
1985	0.3	1.0	2.8	1.6	7.8	0.1	2.3	...
January-April 1986	...	1.3	3.0	1.2	8.4	...	1.8	...
June-September 1986	0.6	0.2	2.4	0.3	5.0	0.2	1.8	0.1

Source: International Food Policy Research Institute survey, 1985/86.

[11]Information provided by the local GBK project office (1986).

Figure 5—Seasonal distribution of off-farm labor, by kind of occupation



Notes: GBK = World Bank project in Gishwati forest (reforestation, infrastructure).
IPV = German agricultural development project.
Minitrape = government road construction program.
Usine à thé = tea factory including factory tea gardens.

Table 25—Off-farm work by type of employment for men, women, and children, 1985 and 1986

Type of Employment	Family Shares of Off-Farm Work, 1985				Family Shares of Off-Farm Work, 1986[a]			
	Total	Men	Women	Children under 16	Total	Men	Women	Children under 16
	(percent)							
Paid agricultural daily work	3.6	77	12	11	2.3	82	14	4
Public projects	32.1	92	8	...	20.9	97	3	...
Tea factory	17.9	64	19	17	30.2	84	8	8
Handicrafts	17.9	100	...	...	11.6	98	...	2
Other	28.6	87	9	4	34.9	88	7	5
Total	100.0	86	9	5	100.0	89	6	5

Source: International Food Policy Research Institute survey, 1985/86.
[a]Only through September.

Table 26 —Off-farm work of men, women, and children, by type of employment and farm-size quartiles, 1986

Type of Employment	Farm Size			
	Smallest Quartile	Second Quartile	Third Quartile	Largest Quartile
	(percent)			
Paid agricultural daily work	11.1	1.5	...	...
Public projects	20.0	6.0	25.7	28.5
Tea factories	33.3	47.8	14.3	13.0
Handicrafts	17.8	16.4	17.1	13.0
Other	17.8	28.4	42.9	45.6
Total	100.0	100.0	100.0	100.0

Source: International Food Policy Research Institute survey, 1985/86.

households; from one-third to nearly one-half of off-farm employment in the two smallest farm-size classes is in these factories. In the larger farm-size classes only very little work time is allocated to the tea factories. For the households with a larger land base, off-farm work in public projects and other work (which includes self-employment and merchant activities) plays a major role. In general, these are jobs with higher wage rates. The result that members of households with larger farms tend to be found in higher-paying jobs may be explained by higher returns to farm labor (opportunity costs) in the larger farm-size groups.

Household-Level Determinants of Off-Farm Work

Obviously, a number of interacting factors determine the total amount of off-farm work time spent by the households: among these are the opportunity costs of time spent away from the own farm, the off-farm wage rate, certain human capital characteristics, and the demographic characteristics of the household. An attempt is made in the following to explain the allocation of work time to off-farm work in a regression model corresponding to equation (6) in the concept described in Chapter 4. The dependent variable in the model is the days of off-farm work per household during the survey period in 1986. It was hypothesized that increased returns to labor on the own farm reduces time allocated to off-farm work. The opposite is expected from a rising wage rate offered in the off-farm labor market. From a larger work force in the household, an increased allocation of time is to be expected for off-farm work, but—because of the rigidities of the off-farm labor market by gender—not if the share of women in the work force is increased. The estimation results of the model are presented in Table 27.

The model results in Table 27 show that increased labor productivity in agriculture significantly reduces off-farm labor supply by the households as expected. A 10 percent increase in agricultural labor productivity reduces off-farm work time by the households by 2.6 percent. This suggests that agricultural technology that increases labor productivity would significantly reduce the pressure on the off-farm labor market and thereby probably have favorable wage rate and employment effects for the growing landless population.

An increased wage rate in the off-farm labor market works in the opposite direction, but the parameter estimate is not statistically significant. This is not too surprising, given the rigidities in the labor market in which formal employment in public projects with

Table 27—Regression analysis of allocation of work time to off-farm work

Explanatory Variable[a]	Parameter	t-Value	Mean of Variable	Standard Deviation
AGRLABP	-0.5746	-2.39	27.58	21.02
WAGE	0.0667	1.00	142.20	77.05
WSHARE	-84.3640	-2.96	0.51	0.18
PERSWORK	18.2594	5.61	3.19	1.56
Constant	47.5620	1.98		
$\hat{R}^2$	0.21			
F-value	12.04			
Degrees of freedom	182			

Note: The dependent variable is OFFWORK = days of off-farm work per household (1986, January-September)

[a]Definitions of variables:

AGRLABP = net returns in agriculture per available labor day (in FRw; labor days available as defined in agricultural labor productivity model, Table 23).
WAGE = off-farm wage rate per day (in FRw).
WSHARE = share of women in household among adults.
PERSWORK = adult persons in household.

fixed wage rates coexists with a free labor market in which minimum wages are hardly enforced. As the model captures neither this nor dynamic changes and risks in the alternative employment categories, the wage effect is not strong.

As expected, larger households send more persons into the off-farm labor market, but less so if women hold an increased share in the household work force (see variables WSHARE and PERSWORK in Table 27).

Summary of Findings

Commercialization of the rural economy in this setting is driven by rapid population growth, which increasingly puts pressure on the nonagricultural rural labor market.

The commercialization process at this location is broad-based and is not the effect of a single specific project or program activity. The agricultural commercialization process is partly driven by opening up new lands for potato production and by the introduction of tea cultivation and tea processing. For low-income households, however, both of these processes are less important than endogenous commercialization through home manufacturing of sorghum beer. Rural development programs of various types play an important role in the overall commercialization process. They do, however, represent a substantial instability in the nonagricultural rural labor market.

Women are the key labor force in agriculture, providing about 70 percent of labor input. Their participation in the new cash crop production (potatoes as a modern input) is, however, relatively reduced as compared with staple food production. Introduction of accelerated technological change in cash crops and subsistence food crops has to focus on women farmers in order to have broad outreach and impact.

Subsistence orientation of agriculture remains the major focus of the farm population. Increased person-land ratios, which will continue to rise because of rapid population growth, will further reduce market integration of agriculture if the market environment does not become less risky and if off-farm employment opportunities do not increase.

In a situation of low levels of labor productivity and low employment growth in agriculture, labor is increasingly pushed into off-farm low-productivity employment. Diversification of income sources as a mechanism to cope with risk in both sectors is adopted by households. Increased labor productivity in agriculture induced by technological change would provide better employment possibilities for the growing landless rural population.

While endogenous rates of technological change are found to be high and significant, the incremental technological change required to be introduced by research, extension, and input provisions beyond current levels would have to be at least 1.4 percent a year just to maintain the current low levels of labor productivity in agriculture. Reasonably high levels of production elasticities of capital in agriculture suggest increased emphasis on rural financial institutions to support rapid technological change in the smallholder agricultural sector.

6

CONSUMPTION RELATIONSHIPS AND EFFECTS OF COMMERCIALIZATION

Hypotheses explored in this chapter relate to the effects of commercialization on food consumption. First, basic relationships between income and expenditure and between income and food-energy consumption relationships are analyzed. The authors then focus specifically on the hypotheses that income from cash crops and male-controlled cash income alters spending on food consumption.

Food from Own Production and Food and Nonfood Purchases

Rural households in Rwanda spend most of their available resources on food, whether own-farm production resources or earned cash income converted to food. Fifty-eight percent of average total household expenditures (including the value of food produced for own consumption) are spent on basic food items, such as pulses, cereals, roots, and tubers. The overall spending on food by households—that is, the share of total expenditures—does not change very substantially across expenditure classes in the sample, which can be attributed to the generally low level of income. About 60 percent of the value of all food and beverage consumption is represented by the households' own-produced food. This is somewhat less in the top expenditure quartile.

The pattern of expenditures on nonfood in relative terms shows little change among the bottom three quartiles, but some change in the top expenditure quartile toward a higher propensity for spending on housing and celebrations and luxuries (Table 28). The more detailed data presented in Table 29 also suggest that with increased income above a certain level—that is, in the third and top expenditure quartiles—more is spent for health care.

Some interesting patterns are visible when expenditures for food are disaggregated (Table 29). Sweet potatoes show up as the staple food of the poor, representing 12 percent of all consumption expenditures in the bottom quartile but less than 5 percent in the top quartile. On the other hand, very high income elasticities indicated by a simple approximation are found for sorghum (4.73), new cereals (such as wheat and rice, which dominate in commodity group 6, 2.96), bottled beer and soft drinks (3.86), animal products (4.29), and sugar (3.17). The low income elasticity of maize (0.48) compared with sorghum is also noteworthy. These elasticities explain why the overall level of the budget share to food remains surprisingly stable across income levels: the composition of the food basket changes considerably with rising income toward more expensive foods and variety in the diet.

Among the nonfood items that grow disproportionately with rising income are especially house building and repair (elasticity of 4.31), celebrations and related gifts (6.95), and health (2.28), as well as expenditures on items such as bicycles, watches, and radios (4.21).

Table 28—Expenditure shares of foods and nonfoods, by expenditure quartiles, 1986

	Share of Total Expenditures[b]				
Foods/Nonfoods[a]	Bottom Quartile	Second Quartile	Third Quartile	Top Quartile	Average
			(percent)		
Foods					
Pulses (1)	27.4	25.4	25.3	23.6	24.9
Cereals, roots, tubers (2-6)	34.2	34.5	35.0	31.2	33.2
Other foods, beverages (7-13)	18.2	21.1	19.8	22.9	21.1
Total food	79.8	81.0	80.1	77.7	79.2
Own-produced (percent of total food)	(62.6)	(61.8)	(64.9)	(55.9)	(60.3)
Nonfoods					
Clothing (14)	8.1	7.1	8.3	7.2	7.5
Housing (15)	1.4	1.6	1.6	4.4	2.8
Household goods (16-18)	5.6	5.7	5.0	4.1	4.8
Celebrations, luxuries (19,22)	0.6	0.6	1.2	2.7	1.7
Other nonfoods (20,21,23)	4.5	4.0	3.8	3.9	4.0
Total nonfood	20.2	19.0	19.9	22.3	20.8
Total expenditures[b]	100.0	100.0	100.0	100.0	100.0
Own-produced food (percent of total expenditures)	(50.0)	(50.0)	(52.0)	(43.5)	(47.8)

Source: International Food Policy Research Institute survey, 1985/86.

Note: Annualization of expenditure shares is based on consumption surveys, January-September 1986.

[a]The figures in parentheses refer to the commodity classifications and expenditure items in Table 29.

[b]This includes the value of own-produced food consumed in the household.

Expenditures on food and nonfood changed considerably during the seasons of the study period in 1986. Average monthly expenditures were highest in the first months of the year but dropped to 76 percent of that level in the April-June period and to 71 percent in July-September. The drop in total consumption was higher among the poor—that is, the bottom quartile—than it was among the top quartile of the households (Table 30). Much of this change in total consumption over the seasons is due to reduced consumption from own-produced food. The further the observations are past the main harvest period early in the year, the lower the consumption from own-produced food. Again, a more pronounced drop in consumption from own-produced food over the seasons is found among the households in the bottom quartile of the expenditure distribution. Later in the year, these households spent increased amounts of resources on purchased food, which is not the case in absolute terms among the top-quartile households. In fact, an opposite direction shows up in spending on food purchases over the season among the poor versus the "rich" households (Table 30, columns 2 and 5, rows 4-6). Also, it is noteworthy that in all seasons the top-quartile households spent about four to five times as much cash for food purchases in the market as households from the bottom quartile. Lower levels of availability of own-produced foods for consumption are combined with lower income levels.

Table 29—Annual expenditures on foods and nonfoods, by quartiles of total expenditure per capita, 1986

Foods/Nonfoods	Annual Expenditure per Capita Bottom Quartile	Second Quartile	Third Quartile	Top Quartile	Average	Approximate Income Elasticity[a]
			(FRw)			
Foods						
1. Peas and beans	1,730	2,208	2,954	4,487	2,845	0.79
2. Potatoes	689	1,018	1,834	2,489	1,507	1.29
3. Sweet potatoes	760	945	868	877	863	0.08
4. Maize	529	656	797	1,042	756	0.48
5. Sorghum	89	265	373	939	417	4.73
6. Wheat, rice, bread, manioc, cooking bananas, colocase, soya	86	116	233	601	259	2.96
7. Sorghum and banana beer	603	952	1,121	1,842	1,130	1.02
8. Bottled beer and soft drinks	30	21	98	264	103	3.86
9. Animal products	105	277	353	1,018	438	4.29
10. Vegetables and fruits	260	377	475	723	459	0.88
11. Sugar	29	69	59	215	93	3.17
12. Oil	41	32	62	87	56	0.56
13. Other	82	107	146	203	133	0.73
Total food	5,033	7,043	9,373	14,787	9,059	0.96
Own production	3,151	4,350	6,079	8,272	5,463	0.80
Nonfoods						
14. Clothing	504	607	966	1,375	863	0.86
15. House building and repair	87	142	191	845	316	4.31
16. Toilet utensils	144	223	227	277	218	0.46
17. Household supplies	107	136	200	272	179	0.76
18. Energy (firewood, coal, batteries, kerosene)	103	138	160	222	156	0.57
19. Celebrations and gifts	27	35	120	406	147	6.95
20. School (tuition, uniforms, paper)	93	77	113	142	106	0.26
21. Health	60	75	123	336	148	2.28
22. Bicycles, watches, radios	12	20	20	114	42	4.21
23. Other	133	196	205	261	199	0.48
Total nonfood	1,270	1,649	2,325	4,250	2,374	1.16
Total expenditures	6,303	8,692	11,698	19,037	11,433	...

Source: International Food Policy Research Institute survey, 1985/86.

Note: Annualization of expenditures is based on consumption surveys, January-September 1986.

[a]These elasticities (Σ_i) are not estimated econometrically, but a rough approximation is computed as follows:

$$\Sigma_i = [(EX4_i - EX1_i)/EX1_i]/[(EXT4 - EXT1)/EXT1],$$

where

Σ_i = approximate income elasticity,

$EX4_i$ ($EX1_i$) = per capita expenditure on expenditure item i in fourth quartile (first quartile), and

EXT4 (EXT1) = per capita total expenditure, including value of own-produced food (income proxy).

Table 30—Monthly expenditures on foods and nonfoods per capita in different seasons, 1986

Expenditure Type/Season	Bottom Quartile			Top Quartile			Average of All Cases		
	FRw	Relative Change (Jan-Mar=100)	Percent of Total in Each Season	FRw	Relative Change (Jan-Mar=100)	Percent of Total in Each Season	FRw	Relative Change (Jan-Mar=100)	Percent of Total in Each Season
Own-produced food									
January-March	325	100	57.9	1,044	100	52.0	619	100	53.5
April-June	218	67	51.8	627	60	40.3	398	64	45.6
July-September	140	43	39.4	599	57	38.7	349	56	42.3
Purchased food									
January-March	124	100	22.1	650	100	32.3	330	100	28.5
April-June	129	104	30.6	561	86	36.1	294	89	33.6
July-September	133	107	37.5	507	78	32.7	271	82	32.8
Total food expenses									
January-March	449	100	80.0	1,694	100	84.3	949	100	82.0
April-June	347	77	82.4	1,188	70	76.4	692	73	79.2
July-September	273	61	76.9	1,106	65	71.4	620	65	75.2
Nonfood expenses									
January-March	112	100	20.0	315	100	15.7	208	100	18.0
April-June	74	66	17.6	367	117	23.6	182	88	20.8
July-September	82	73	23.1	442	140	28.6	205	99	24.8
Total expenditures									
January-March	561	100	100.0	2,009	100	100.0	1,157	100	100.0
April-June	421	75	100.0	1,555	77	100.0	874	76	100.0
July-September	355	63	100.0	1,548	77	100.0	825	71	100.0

Source: International Food Policy Research Institute survey, 1985/86.

Determinants of Subsistence Orientation in Consumption

The production-related analyses in the previous section showed that numerous factors determined the level of subsistence orientation in the farm households. Consumption issues certainly rank high among the households' decision variables concerning subsistence orientation in production. In the following, an attempt is made to identify the major factors that determine this subsistence orientation in consumption by means of a multivariate analysis. This analysis refers to subsistence concept 3 (CX), defined in equation (4) in Chapter 4. It also refers to the theoretical foundation discussed in Chapter 4.

In specifying the model, it was hypothesized that subsistence orientation is determined by availability of production resources and thus by factors that influence the income-earning capacity from agricultural sources. The critical variable that depicts this in the model is the person-land ratio (PLR in Table 31).

Second, it was hypothesized that a higher capital asset base (CAPITAL) reduces pressure on households to avoid production risks and permits more specialization in profitable crops, thus more market integration of the household economy, and thus reduced subsistence orientation.

Third, it was hypothesized that access to off-farm wage employment reduces subsistence orientation because of expanded exchange entitlements.

Table 31—Regression analysis of determinants of the degree of subsistence orientation in consumption

Explanatory Variable[a]	Parameter	t-Value	Mean	Standard Deviation
PLR	-0.5737	-4.40	11.16	8.25
CAPITAL	-0.0101	-2.13	219.50	220.08
WAGES	-7.8941	-2.85	0.48	0.37
RISKPER	-13.9794	-5.47	2.35	0.40
CHSHARE	15.7188	2.99	0.29	0.20
Constant	24.2187	3.62	...	...
$\hat{R}^2$	0.50			
F-value	13.11			
Degrees of freedom	177			

Note: The dependent variable is the value of own-produced food consumed by the household in percent of total food and nonfood consumption value (including own-produced); CX x 100, as defined in concept 3 in Chapter 4.

[a]Definitions of variables:

PLR = person-land ratio, in persons per hectare (persons per hectare, rather than adult-equivalent persons as in the production analysis, are used here to also account for demand effects).

CAPITAL = household capital stock per capita.

WAGES = wage income over total cash income in current year.

RISKPER = index of household head's perception about crop risks (derived from a specific crop-choice survey; index is the mean of stated level of importance of crop-specific risk on a scale of 1 to 3).

CHSHARE = share of children under five years of age in persons in household.

Fourth, it was noted that individual attitudes and perceptions may influence household choices regarding more or less subsistence orientation. Critical in this respect is a household's perception (that of the wife or husband or both) of crop risks. From a specific survey component (see Table 19) inquiring into household crop-risk perception, a respective variable is derived (RISKPER).

Finally, it was hypothesized that a household's demographic composition, especially a higher share of children in the household (CHSHARE) would have an increasing effect on subsistence orientation. The expectation is that a stronger focus on household production-based food security would be found in households with more small children, where women have less mobility to get involved in off-farm work, which in the study area usually entails long-distance walking and absence from home for long hours.

The results of the regression model (Table 31) suggest a very strong effect of changes in the person-land ratio for subsistence orientation. They also indicate a statistically significant effect of capital assets for reduced subsistence orientation.

The model further suggests that access to wage employment reduces subsistence orientation. Support is also lent to the hypothesis that households with more concern for crop risk have a higher subsistence orientation—consistent with the sample theoretical model in Figure 4. Moreover, life cycle impinges on household economic orientation: households with small children focus more on subsistence orientation.

Most interesting is the level of the effect of reduced availability of land per person on the subsistence orientation in consumption. At sample means, one additional person per hectare reduces the subsistence share by 0.57 percent. Or, in other words, a 10 percent increase in the person-land ratio leads to a reduction in the subsistence share of total expenditures by 1.3 percent. Although statistically highly significant, the level of this reduction, at first glance, is surprisingly low. Two factors are at work here that leave the CX rather stable:

$$CX = X_s / X_{tot}. \tag{9}$$

First, an increase in the person-land ratio (PLR) implies some reduction in agricultural income-earning capacity. Thus, total consumption value (X_{tot}) as an income proxy—the denominator in the dependent variable—is expected to drop with rising PLR, leaving the share of subsistence in total consumption high. Thus,

$$PLR \uparrow \rightarrow X_{tot} \downarrow .$$

Second, reduced farm size leads to an increased subsistence orientation (X_s) in the use of the remaining land resources for various reasons discussed earlier, that is, the desire to maintain food insurance (see Chapter 5 and Table 7). Thus,

$$PLR \uparrow \rightarrow X_s \uparrow .$$

In combination, both of these forces work in the direction of a rather stable and high share of subsistence food in total consumption when land gets scarcer. Nevertheless, at current population growth rates, the person-land ratio will increase from 11.2 to 16.9 persons per hectare within one decade. This would, other things holding constant, reduce subsistence orientation by 3.3 percentage points from its current level of 47.8 to 44.5 percent.

Subsistence and Incremental Spending on Food

Two key questions in the context of this study are to what extent incremental expenditures of the households are spent on food and to what extent reduced subsistence orientation impinges on the allocation of means to food consumption. These questions are further evaluated on the basis of a simple Engel curve estimation and thereafter with a model for food-energy consumption. The effects of changes in the CX variable, explained above (Table 31), are thus traced to food expenditures and calorie consumption.

The model explains total expenditures for food (including the value of consumed own-produced food) as a function of total income (for which the aggregate total expenditure values serve as a proxy variable), household size and composition of the household, and the degree of subsistence orientation in the household (see Table 32). This specification of the Engel curve estimation tests the hypothesis that an increased subsistence orientation of the household increases the overall allocation of resources to food consumption, holding income constant. It was further hypothesized that in female-headed households, more is spent on food consumption, holding other things constant. This is a test for the expectation that in households where budget allocations are largely controlled by women, more is spent on basic welfare-related items, such as food, health,

Table 32—Model of determinants of food expenditures

Explanatory Variable[a]	Total Sample Parameter (and t-Value)	Mean	Standard Deviation
ln TOEXCA	8,605.518 (19.52)	9.24	0.43
SUBFOOD	37.703 (3.40)	49.04	15.58
ln CAPITA	-129.491 -0.30)	1.62	0.46
FEMHEAD	1,295.174 (2.28)	0.11	0.32
CHSHARE	1,125.520 (1.23)	0.29	0.20
Constant	-73,810.317 (-16.30)	...	...
Dependent (FOODEX)	...	7,826.38	4,410.35
$\hat{R}^2$	0.722		
F-value	98.4		
Degrees of freedom	182		

Note: The dependent variable is FOODEX = expenditure on all food per capita per year (in FRw), including value of consumed own-produced food.

[a]Definitions of variables:

TOEXCA = logarithm of total expenditure per capita.
CAPITA = household size (persons).
FEMHEAD = female-headed households=1, else=0.
SUBFOOD = consumed own-produced food in percent of total expenditures.
CHSHARE = share of children under five years of age in persons in household.

and expenses related to child nurturing. It was finally hypothesized that in larger households, less is spent on food per capita because of potential economies of scale.

The parameter estimates (Table 32) suggest that a 10 percent increase in income (total expenditure) leads to a 10.5 percent increase in food expenditure at sample mean values. As discussed at the outset of this chapter, the tabulations show that a major change in the food basket composition occurs as households become richer and spend more on expensive food items. This is again reflected in the high expenditure elasticity of food found in this model.

More surprisingly, the model results suggest a strong impact of subsistence orientation on food expenditures: a drop of the subsistence share (CX) by one percentage point reduces the total food consumption value, all else remaining the same, by 0.47 percent.

Support is also lent to the hypothesis that female-headed households in general spend more on food consumption at a given income level and level of subsistence orientation than do male-headed households. On average, female-headed households are found to spend 16 percent more on food than do other households at the same income level (size and demographic pattern). To what extent these differences in spending behavior translate into food-energy consumption will be evaluated in the following chapter.

From these analyses, it is concluded that much of incremental income in these communities is spent on food, but that with rising income the food basket substantially changes toward more expensive food items, thus keeping the share of total food expenditures in total expenditures remarkably constant and at a very high level. Within the same income group, reduced subsistence orientation is found to reduce overall spending on food. This phenomenon, also found elsewhere (von Braun, Hotchkiss, and Immink 1989), may be attributed to changes in intrahousehold income control and responsibility, and possibly to fluctuating, more lumpy cash-income sources. The role of transaction cost differentials of household food versus food from the market requires further exploration.

Composition of Food-Energy Sources

In the following analysis, the focus is on the effects of changes in income and income composition on food-energy consumption at the household level. While it was observed in the expenditure analysis above that households spend the major share of incremental income on food, it is not immediately clear to what extent these incremental expenditures actually lead to incremental food consumption in terms of food energy. In fact, lower income elasticities of calorie consumption are expected, because substantial shifts were observed within the food basket toward more expensive calories when income increases.

The focus on food energy (calories) is because of a hypothesized strong relationship between energy deficiency and nutritional status in this study region and particularly in the poorest households. This is not to say that other food deficiencies, such as proteins, micronutrients, and vitamins—especially vitamin A (Vis, Yourassowsky, and van der Borght 1975)—are not of considerable importance in the highly variable Rwandan local context.

The demand of households for food is not necessarily driven by a perceived demand for food energy. Even at low-income levels, households demand not only low-cost food in terms of cost per calorie but also variety in the diet and a food composition that is seen to be appropriate given certain acquired perceptions and food habits at the specific location.

Although Rwanda is frequently mentioned as a country where rural communities have a very homogeneous diet, this understanding of Rwanda's rural food consumption situation is probably a result of assessments of the consumption situation that are too aggregated.

A disaggregated evaluation of food consumption patterns and food-energy sources as presented in Table 33 shows substantial shifts in the composition of the major sources of energy in the diet when income increases. The figures presented in the table are expressed in terms of calories per day per adult-equivalent person, not on a per person level.[12] They show that in the mid-year survey round in April-June 1986, average calorie consumption stood at 2,643 calories per adult-equivalent in the sample. For comparative purposes, consumption of food energy on a per person per day basis was 2,025 calories (see Table 34). This compares with the average per person dietary-energy supplies of 2,274 calories per day for the country as a whole in the FAO (1985) Fifth World Food Survey.

Looking at individual commodities, most noteworthy in Table 33 is the inferiority of sweet potatoes as indicated by a reduction in the share of sweet potatoes in total calories consumed from 40 percent in the bottom expenditure quartile to 15 percent in the top quartile. This change not only reflects a relative reduction but also an absolute reduction of sweet potato consumption as income increases; or the other way around, increased impoverishment in the area would very substantially lead to increased consumption (and production) of sweet potatoes. This finding is much in line with the findings of Laure (1982, 188) in a neighboring lower-altitude region.

Opposite to sweet potatoes is the consumption behavior toward potatoes, which have a share of 8 percent in the bottom quartile, but 18 percent of calorie consumption in the top quartile. Compared with these substantial changes, the relative positions of pulses and of cereals in calorie consumption change very little (Table 33). Overall calorie consumption, however, is 66 percent higher in the top expenditure quartile in per capita terms than it is in the bottom quartile.

In the whole sample, sweet potatoes provide on average the largest share of all food calories consumed, with 26 percent, followed by peas and beans together covering 25 percent of food energy, and these are closely followed by maize (the major cereal) which covers 23 percent of total calories. The next most important energy sources are potatoes, sorghum beer, and sorghum.

Effects of Subsistence Orientation, Income, and Land Scarcity on Food Consumption

In a different arrangement of calorie consumption figures by degree of subsistence orientation of households, applying concept 3 of subsistence (CX) as presented in Table

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[12]For computation of adult-equivalents, a World Health Organization (1985) report was consulted. (For children from 1 month to 18 years old, age-related Tables 22, 24, and 25 gave energy-requirement figures. Table 14 was used to estimate the basal metabolic rate [BMR] for different age and height groups of men and women; the BMR was multiplied by the factor for moderate activity from Table 16.) The adult-equivalents in the households refer to the requirement of an average 30-year-old male in the sample of the present study, 2,798 calories a day.

Table 33—Sources of calories per adult-equivalent per day, by expenditure quartiles, April-June 1986

Food Item	Bottom Quartile		Second Quartile		Third Quartile		Top Quartile		Average	
	Calories/ Day/Adult-Equivalent	Percent of Total Calorie Intake	Calories/ Day/Adult-Equivalent	Percent of Total Calorie Intake	Calories/ Day/Adult-Equivalent	Percent of Total Calorie Intake	Calories/ Day/Adult-Equivalent	Percent of Total Calorie Intake	Calories/ Day/Adult-Equivalent	Percent of Total Calorie Intake
Peas and beans	451	23.0	606	23.5	644	23.1	915	28.2	653	24.7
Potatoes	164	8.4	237	9.2	495	17.8	598	18.3	372	14.1
Sweet potatoes	791	40.0	767	29.9	713	25.5	490	15.0	691	26.2
Maize	366	18.6	690	26.8	644	23.1	767	23.5	616	23.3
Sorghum	16	1.0	46	1.8	43	1.5	129	4.0	58	2.2
Wheat, rice, bread, manioc, cooking bananas, colocase, soya	37	1.9	10	0.4	21	0.8	86	2.6	38	1.4
Sorghum beer	67	3.4	117	4.5	122	4.4	150	4.6	114	4.3
Bottled beer and soft drinks	2	0.1	0	0.0	9	0.3	4	0.1	4	0.2
Animal products	7	0.4	8	0.3	30	1.1	25	0.8	17	0.6
Vegetables and fruits	52	2.6	79	3.1	50	1.8	69	2.1	62	2.3
Sugar	2	0.1	8	0.3	5	0.2	8	0.2	6	0.2
Oil	9	0.5	6	0.2	10	0.4	21	0.6	12	0.5
Total	1,964	100.0	2,574	100.0	2,786	100.0	3,262	100.0	2,643	100.0

Source: International Food Policy Research Institute survey, 1985/86.

Table 34—Calorie consumption per person, by expenditure and farm-size quartiles, survey round 2, May-June 1986

Quartile	By Expenditure Quartile: Average Annual Total Expenditure/ Capita[a]	Calories/ Person/ Day	By Farm-Size Quartile: Average Farm Size	Calories/ Person/ Day
	(FRw)		(hectares)	
Bottom	6,303	1,360	0.23	1,845
Second	8,692	1,790	0.45	1,735
Third	11,698	2,089	0.75	2,039
Top	19,037	2,631	1.53	2,202
Average	11,433	2,025	0.74	2,025

Source: International Food Policy Research Institute survey, 1985/86.
[a]The expenditure classes are formed on the basis of annual per capita expenditure data from all survey rounds (including consumption of own-produced food).

35, it appears that per capita calorie consumption increases with increased subsistence orientation: the top quartile in terms of subsistence orientation consumes 20 percent more per adult-equivalent person than the bottom quartile. These changes in levels of consumption are not combined with major shifts in the composition of the diet. An exception may be for maize, where in the bottom quartile a substantially smaller share of calories is provided by this crop than in all other quartiles.

Overall, per capita calorie consumption shows a positive correlation with farm size, which is not surprising given the relationship between farm size and income level (Table 34). More surprising is that calorie consumption does not really increase very much with rising farm size: in farms that have an average of 0.23 hectares (the bottom quartile), calorie consumption is only 16 percent lower than in the top quartile, which averages 1.53 hectares. This means—in a rough calculation that takes into account the differences in household size per farm—that a reduction in average farmland per capita by 10 percent is associated with a reduction in calorie consumption by only 2.1 percent. Intensification of agricultural production on a more limited land base and increased off-farm income largely permit the maintenance of food-energy consumption.

While the relationship between farm size and food consumption at the household level appears rather weak, the relationship between income and food-energy consumption is very strong. A first indication of this is given by the comparative tabulation in Table 34, which shows calorie-consumption levels per capita by expenditure quartiles (as a proxy variable for per capita income) in comparison with farm-size quartiles. In the breakdown by expenditure quartiles, calorie consumption per capita is 93 percent higher in the top expenditure quartile than it is in the poorest group, while the bottom quartile has an average expenditure per capita that is 67 percent below the top quartile's average. A comparison of these associations of income and farm size in food-energy consumption—in a simple approach from the relative differences in farm size, income, and calories between the top and bottom quartiles (Table 34)—suggests that a doubling of farm size is associated with a 3.4 percent increase in calorie consumption, but a doubling of income

Table 35—Calories per adult-equivalent per day, by subsistence quartiles, April-June 1986

Food Item	Bottom Quartile (Least Subsistence-Oriented)		Second Quartile		Third Quartile		Top Quartile (Most Subsistence-Oriented)		Average	
	Calories/ Day/Adult-Equivalent	Percent of Total Calorie Intake	Calories/ Day/Adult-Equivalent	Percent of Total Calorie Intake	Calories/ Day/Adult-Equivalent	Percent of Total Calorie Intake	Calories/ Day/Adult-Equivalent	Percent of Total Calorie Intake	Calories/ Day/Adult-Equivalent	Percent of Total Calorie Intake
Peas and beans	656	26.8	542	21.7	547	20.1	871	29.6	653	24.7
Potatoes	323	13.3	304	12.2	456	16.8	407	13.9	372	14.1
Sweet potatoes	622	25.5	695	27.8	678	25.0	773	26.4	691	26.2
Maize	448	18.4	620	24.9	744	27.4	653	22.3	616	23.3
Sorghum	106	4.4	24	1.0	73	2.7	28	1.0	58	2.2
Wheat, rice, bread, manioc, cooking bananas, colacase, soya	68	2.8	41	1.6	17	0.6	27	0.9	38	1.4
Sorghum beer	98	4.0	167	6.7	90	3.3	99	3.4	114	4.3
Bottled beer and soft drinks	4	0.2	8	0.3	1	0.0	1	0.0	4	0.2
Animal products	16	0.7	9	0.4	29	1.1	15	0.5	17	0.6
Vegetables and fruits	64	2.6	71	2.8	60	2.2	55	1.9	62	2.3
Sugar	11	0.5	4	0.2	6	0.2	2	0.1	6	0.2
Oil	20	0.8	9	0.4	16	0.6	1	0.0	12	0.5
Total	2,436	100.0	2,494	100.0	2,717	100.0	2,932	100.0	2,643	100.0

Source: International Food Policy Research Institute survey, 1985/86.
Note: Subsistence is defined as the value of own-produced food in percent of total expenditures (concept 3, see Chapter 4).

is associated with a 46 percent increase in calorie consumption.[13] Income and food-energy consumption relationships and the impact of changes in subsistence orientation are further analyzed below in a more refined model analysis.

Specific Home Goods Production: Water and Wood

The picture of income-expenditure-consumption links would remain incomplete without looking into specific home goods production, especially water and fuelwood acquisition. Water and wood fetching are time-consuming activities. The amount as well as the quality of water and wood gathered can influence sanitation, food preparation, and heating. Water and wood fetching compete with other activities for time.

Water fetching takes about half an hour a day and is performed almost exclusively by women and children. Time for collecting wood adds up to about nine hours per week per household. In two-thirds of all households, only women and children collect wood. Time allocation variables for fetching water and wood are highly correlated with each other.

Table 36 shows the discussed variables broken down by the three cutoff points of calorie consumption. The group with the highest calorie deficiency spends significantly more time on water and wood fetching than the other groups. The share of households that have to buy wood doubles from 8 percent for the best-off group to 16 percent for the worst-off group. These calorie-deficient households tend to live in the most marginal locations, which are disadvantageous for water and wood collection. It may hold that the poorest tend to be short not only in money but also in time, and time constraints are passed on to the children in this group; the percentage of poor households in which only children fetch water or wood increases substantially over that of better-off households, while women's involvement in this activity decreases. Women of calorie-deficient households obviously do not have time to get water or wood. The above analyses show that farmers in the surveyed area react to a rising person-land ratio by changing calorie production toward cheaper calories and higher output per unit of land and by intensifying labor input. It is therefore concluded that the rapid increase of children's work in household services (water, wood) in these calorie-deficient households may suggest that the subsistence food producers (which means the women) have reached a point where they devote all their efforts to subsistence production without being able to generate enough food.

Chronic and Transitory Food-Energy Deficiencies

The main interest of this study is households at the bottom end of the income scale—the prevalence and nature of their food deficiencies and how these deficiencies are affected by market integration and commercialization of traditional agriculture. Thus it

[13]It should be noted that this simple calculation neglects the fact that the relationships are not linear between bottom and top quartiles. As shown in Table 34, the second farm-size quartile is even at a somewhat lower calorie-consumption level than the bottom quartile. Land per capita is not linearly related to farm-size differences, as the smallest farms have smaller families. Still, doubling of land per capita in the above calculation is associated with an increase in calorie consumption by only 5.7 percent.

Table 36—Time spent on household water and wood fetching, by calorie consumption group, 1985/86

Item	Calorie Consumption Group			
	More Than 80 Percent of Requirements	60-80 Percent of Requirements	Less Than 60 Percent of Requirements	Total Average
Water				
Time fetching water (minutes/day/household)	34*	34	48*	36
Time share of family members (percent of household time)				
Woman only	46**	34	16**	38
Child(ren) only	27**	36*	53*,**	33
Woman and child(ren)	23	27	30	25
Family, including husband and others	4	3	1	4
Wood				
Time fetching wood (hours/week/household)	9	7**	11**	9
Time share of family members (percent of household time)				
Woman only	40**	27	22**	34
Child(ren) only	11	14	21	13
Woman and child(ren)	22	19	22	21
Family, including husband and others	27	40	35	32
Share of sample households that purchase wood (percent)	8	4	16	8
Share of sample households with own wood fields (percent)	32**	56**	44	39

Source: International Food Policy Research Institute survey, 1985/86.

*Denotes pairs of groups significantly different at the 0.10 level.

**Denotes pairs of groups significantly different at the 0.05 level.

is relevant to look into fluctuations in energy deficiency during the year. In the mid-year survey in May/June 1986, 41 percent of all households were found to consume less than 80 percent of calorie requirements. In the third survey round in August/September, this share had increased to 62 percent.

The detailed and carefully done study in a neighboring lower-altitude zone by Laure (1982, 154), based on a smaller sample that is traced over a full year, shows similar large seasonal variations in calorie consumption. In that sample the percentage of households below 80 percent of recommended calorie requirements varies between 35 percent of households during January and June (1980) and 70 percent of households during August and December.

Surveys like this, which consist of a series of recall surveys that cover consumption over a short period (in this case, it is a week in each survey round), suffer from the problem of erratic fluctuations because of special incidents affecting household consumption levels at any given point in time. Examples of interfering events are, for instance, festivities, visits, and absence of certain household members. Over time these fluctuations should be expected to level off; therefore, households that for special reasons unrelated to income were found in, for instance, the calorie-deficient group of sample households at one point, would probably not be found in that group again during a later survey round. This should, of course, not be expected on average over time for these poor whose consumption also fluctuates but is in general below requirements due to lack of income and other entitlement failures that make them chronically food insecure.

A rather high persistence of low-end poverty is found to be represented by a fair amount of stability of household consumption deficiencies in the sample. Of the 41 percent of households below 80 percent of requirements in the May/June survey, 70 percent had been in that group in the first survey round in February/March. Sixty-five percent of the households in the calorie-deficient group in August/ September had been found in the same group in May/June. This persistence in low-end poverty, as represented by continuous calorie deficiencies, has implications for policy interventions for nutritional improvement. Targeting of measures for nutritional improvement and for income and employment generation may have a much more effective result if directly geared toward these low-end poverty groups. Frequently, and not only in Sub-Saharan Africa, fluctuations in poverty are a phenomenon that complicate policy intervention. To some extent, this is the case in the study area, but a fair amount of persistent and stable low-end food poverty is still found and requires the attention of program designers and policymakers.

Determinants of Calorie Consumption

The above discussion on relationships derived from simple tabulations on the structure of calorie consumption and its differences between various farm-size and income classes reveals a complex problem of a number of exogenous factors that determine actual food-calorie consumption levels.

In the following an attempt is made to explain calorie consumption levels at the household level, and in this context, to evaluate the role of more or less subsistence orientation in food-energy consumption. The model is designed in the following way: dependent variables are calories consumed per day per adult-equivalent person as observed during the three survey rounds in the weekly recall surveys on quantities of food use from stocks and own production as well as food purchases.

The specification of the model and related explanatory variables are based on the following hypotheses. Rising income, as represented by the total expenditures per capita (as an income proxy), leads to increased calorie consumption, but decreasingly so at the margin, which is depicted by a logarithmic transformation of the total expenditure variable (TOEXCA, Table 37).

Increased food prices are expected to lead to reduced calorie consumption, and changes in price ratios in favor of a food item are expected to lead to absolute or at least relative switches toward the lower-calorie food items. These price relationships are depicted by two key crops from the staple food bundle that are much traded—potatoes and sweet potatoes (POTPRICE, POTSWEET). A fair number of regional differences and seasonal price changes in these commodities were captured by the survey at the household level.

It is further hypothesized that an increased share of subsistence food from own production raises overall calorie consumption beyond the income effect of production (SUBCAL). This may be so because of differentials in transaction costs and differentials

Table 37—Determinants of calorie consumption

Explanatory Variable[a]	Parameter	t-Value	Variable	Elasticity at Mean
TOEXCA	1,243.084	20.91	6.70	0.476
POTPRICE	-24.518	-2.44	8.55	-0.080
POTSWEET	-135.269	-1.32	0.84	...
SUBCAL	5.221	3.71	75.91	0.152
CAPITA	-84.951	-6.12	5.51	-0.179
CHSHARE	1,323.005	8.66	0.29	0.147
FEMSHARE	5.122	3.60	15.37	0.030
ROUND 1	496.410	6.29	0.33	0.063
ROUND 2	437.296	5.40	0.33	0.055
Constant	-6,093.713	-13.42	...	...
(CALADEQ)	...	...	2,609.40	...
$\hat{R}^2$	0.598			
F-value	93.1			
Degrees of freedom	549			

Note: The dependent variable is CALADEQ = calories per day per adult-equivalent person.

[a]Definitions of variables:

- TOEXCA = income proxy; logarithm of total expenditure per capita per month in respective survey round (in FRw).
- POTPRICE = price of potatoes in FRw per kilogram.
- POTSWEET = price ratio of potatoes over sweet potato price.
- SUBCAL = consumed own-produced calories in percent of total calories.
- CAPITA = household size (number of persons).
- CHSHARE = share of children under five years of age in persons in household.
- FEMSHARE = female income share over total income.
- ROUND 1 = dummy variable for survey round 1.
- ROUND 2 = dummy variable for survey round 2.

in propensities to consume own-produced versus purchased food. Given the time costs of households in food acquisition from market versus off-take of own-produced food, the transaction-costs argument is probably of greater relevance in this environment where food acquisition requires a substantial time investment in going to market.

Income level, form of income (cash versus kind), and income control within the household may matter for actual levels of food consumption. Regarding income control, it is hypothesized that incremental cash income in the hands of women (FEMSHARE) has an incremental positive effect for food-energy consumption, holding household income constant.

It is also hypothesized that household characteristics have a bearing on the levels of calorie consumption. In larger households, scale economies may be achieved, and therefore per capita calorie consumption may fall, with rising household size (CAPITA); a test is made for changes in average calorie-consumption levels as a function of the share of children in the household population (CHSHARE). The variable CHSHARE depicts two things: first, in general, household calorie consumption per adult-equivalent increases when the share of children under age five increases—this could be partly related to increased energy expenditure of breast-feeding women. Second, the variable depicts and corrects potential estimation problems of the child-specific adult-equivalent rates because these depend partly on the assumed activity levels of children, about which very little is actually known (a "moderate" activity level was assumed). A more than moderate activity level of children would lead to an increased (positive) parameter estimate. This variable thus functions also for corrective purposes to reduce distortions in the analysis.

Finally, differences are sought between the three survey rounds in terms of calorie consumption beyond the above-mentioned factors. Such differences may stem from seasonal variations in energy expenditure due to variation in workload or climatic conditions or both. It was hypothesized that in August, when the lightest workload is observed in agriculture (survey round 3), energy consumption is down because of reduced expenditure of energy.

The model results suggest a strong relationship between income and calorie consumption, thus reaffirming the suggestions derived from the earlier tabulations. A 10 percent increase in income raises calorie consumption at the sample mean by 4.8 percent. Substantial differences exist between the top and bottom income groups' use of incremental income for food energy. An additional FRw 100 (US$1.11) of per capita monthly income would raise household-specific calorie consumption by 6.5 percent in the bottom-quartile households and by 5.5 percent in the top-quartile households.

The calorie-consumption information of this section combined with the expenditure information discussed in the previous section suggests that household spending per calorie increases rapidly with rising income. Calorie consumption per capita increases less than food expenditures across the expenditure quartiles. While the households in the bottom quartile spend an average FRw 7.02 (US$0.08) per 1,000 calories, the households in the top quartile spend 77 percent more (FRw 12.42, or US$0.14).

Clearly, households respond with overall reduced calorie consumption when food prices increase, as indicated by the parameter estimate for the staple food price (potato price, which correlates closely with cereal price). A 10 percent increase in the potato price would reduce calorie consumption by 0.8 percent. On the other hand, no significant relationship is found between changes in the potato and sweet potato price ratio for calorie consumption.

Reduced subsistence orientation is found to reduce calorie-consumption levels. A combination of forces of transaction costs and women's control over subsistence probably are at play here. The effect is statistically significant: a reduction in the share of subsistence calories in total calories by 10 percentage points from, say, the currently high mean of 75 percent to 65 percent would reduce calorie consumption by 2 percent, holding all other variables constant. Thus, reduced calorie availability from own production as a consequence of further-increased land-scarcity effects will have an adverse effect on calories beyond the income-level and income-control effects, though the magnitude of the effect does not seem to be large.

In larger households, less is consumed for every additional person in the household. As indicated by the parameter estimates for the CAPITA variable, an additional person would reduce average calorie consumption levels per capita in the household by 85 calories or 3.3 percent, holding everything else constant. An increased share of children in the household has the opposite effect.

A Special Case: Farmers Displaced by Factories' Tea Plantations

The commercialization effects of agriculture on production, employment, and income take many different forms. The loser-gainer situations in the commercialization process are very complex. One such case is the displacement of farm households by the tea factories in the area. As described in Chapter 3, the establishment of two tea factories in the study area led to the displacement of a considerable number of farm households that had already settled where the factories' tea gardens were later established. The displacements occurred partly in the late 1970s and partly in 1984/85, shortly before the survey for this study was undertaken. A specific subsample of displaced farm households was surveyed to evaluate the short- and medium-term effects of the severe disruption these households had experienced. This small subsample cannot claim to be representative of the effects of expropriation in the tea area in general, but it gives some typical insights.

Compensation

The expropriation of 32 interviewed households occurred between 1977 and 1985. One-half of them were notified in the same year the expropriation took place, so they could hardly plan for the change; one-third were informed a year before the expropriation, and the rest still earlier. All households lost land and 24 (75 percent) also lost their houses. Only those who lost their houses received cash compensation of an average FRw 130,736 (a range of FRw 1,600-500,000), which seems somewhat related to the value of the houses. Most of the 24 households that got compensation received it in the same year as the expropriation (71 percent). Twenty out of the 24 households that lost their houses used part of the compensation to build a new house. Only 19 out of the 32 who lost land purchased new fields. The field purchases of 8 of them are documented and show rather high prices compared with other land purchases recorded in the survey. They reported 148 percent higher prices per hectare than the average price reported for land purchases in the same period by other farm households in the sample who had purchased land. Local immobility and desire for fast acquisition of land after the expropriation may have contributed to the high purchase prices.

Seventy-two percent of all 32 expropriated households reported that they now have a smaller farm than before. Seven of the 8 farms that did not get any cash compensation were able to grow potatoes in the Gishwati forest area. The access or nonaccess to this land in the forest had an important impact on the agricultural production, income, and entitlement to food of the displaced households.

Agricultural Production of Displaced Farmers

The displaced farmers who did not get access to land in Gishwati have, on average, much smaller farms than the rest of the sample (Table 38). In general, fields of the displaced farmers are more frequently on steep slopes or hilltops. They did not have, on average, more access to rented land (17 percent).

The displaced households produce mainly potatoes, though they also have substantial production of maize and pulses, on average similar to other farmers. The comparatively low sweet potato production is due to the specific location of the displaced farmers. They also reported having grown few sweet potatoes before displacement.

Off-Farm Employment

The small farm size of the displaced households (without Gishwati fields) leads to the question of whether they can supplement their modest agricultural income through off-farm work. As Table 39 shows, in April-June 1986 the displaced farmers earned an average of 31 percent more off-farm income than the households that were not displaced. But the displaced farmers without Gishwati fields had absolutely less. All displaced

Table 38—Farm characteristics and production of displaced and other farmers, 1985/86

Item	Not Displaced	All Displaced	Displaced: Without Gishwati Fields	Displaced: With Gishwati Fields
Farm size (hectares)	0.62	0.68	0.47	0.86
Fields on upper hill or top of hill (percent)	30.0	51.0	24.0	60.0
Inherited fields (percent)	44.0	20.0	11.0	23.0
Purchased fields (percent)	17.0	34.0	67.0	24.0
Cash rental fields (percent)	18.0	17.0	17.0	18.0
Fields in Gishwati forest (percent)	10.0	19.0	...	24.0
Harvest (kilograms)[a]				
Potatoes	738	1,226	382	2,525
Peas and beans	83	90	35	133
Maize	97	198	80	294
Sorghum	155	47	...	85
Sweet potatoes	227	26	...	47
Number of households	181	32	21	11

Source: International Food Policy Research Institute survey, 1985/86.
[a]Refers to main crop season only (1985/86).

farmers had a higher proportion of tea-factory work, but none of them had access to employment by public projects.

Income and Consumption

Displaced households earned most of their cash income from off-farm work, potatoes (in Gishwati), and sorghum beer sales. They sold about twice as much sorghum beer as other households, and it appears that this was a main income-earning activity resorted to by women in these households, once their fields were lost.

It is difficult to establish an appropriate income account for the displaced households because of their special situation. Their overall work effort may also be different from the rest of the main sample and could not be assessed appropriately in the survey. Their welfare situation, however, may be reasonably depicted by their food and nonfood consumption and expenditure (Table 40).

The main difference in expenditure patterns between expropriated and other households is the much higher housing expenditure of displaced farmers. Evidently, this reflects the immediate consequence of displacement, including the loss of houses. But also excluding housing, the nonfood expenditures of the displaced households are higher than those of other households. This has not negatively affected food expenditures and calorie consumption in the sample of displaced households. On average, they consume even more than the rest of the sample households in the September/October 1986 survey. Yet it should be noted that only a small sample forms the basis of this comparison. Based on this small sample, there is no indication that food consumption suffered due to the disruption in the displaced households. Despite the reduced farm-resource base, entitlements to food were maintained via the off-farm employment opportunities, the rather special opportunity of potato-growing in the forest area, and the compensation for expropriated houses.

Table 39—Off-farm work of displaced and other farm households, 1985/86

Type of Work/Earnings	Frequency of Work[a]			
		Displaced		
	Not Displaced	All Displaced	Without Gishwati Fields	With Gishwati Fields
	(percent)			
Agricultural daily worker	13.0	13.0	25.0	...
Public projects	16.0	...	...	...
Tea factory	21.0	57.0	58.0	55.0
Craftsmen	13.0	17.0	17.0	18.0
Others	37.0	13.0	...	27.0
Total	100.0	100.0	100.0	100.0
Average off-farm earnings, April-June 1986 (FRw)	1,543	2,028	1,456	2,357
	(100.0)	(131.4)[b]	(94.4)[b]	(152.8)[b]

Source: International Food Policy Research Institute survey, 1985/86.

[a]The numbers represent only frequency, not length, of employment.

[b]Relative to the "not displaced" group = 100.0.

Table 40—Expenditures and food consumption of displaced and other farm households, 1986

Item	Not Displaced	Displaced without Gishwati Fields	Displaced with Gishwati Fields
Total nonfood expenditure (FRw)	167	433	315
House building/repair (FRw)	23	275	120
Nonfood expenditure without house expenditure (FRw)	144	158	194
Total food expenditure (including value of own-produced) (FRw)	565	670	762
Own-produced food (FRw)	305	361	461
Total monthly expenditure without house expenditure (FRw)	709	828	957
Food expenditure in percent of total expenditures without house expenditure	80	81	80
Own-produced food value in percent of total expenditures without house expenditure	43	44	48
Own-produced food expenditure in percent of total food expenditure	54	54	60
Calories per day per adult-equivalent person	2,058	2,718	2,481
Number of households	181	21	11

Source: International Food Policy Research Institute survey, 1986.

Note: Data in this table are for September/October 1986, when the special survey of displaced households was included (round 3 of survey).

This result should not be misinterpreted to mean that all displaced households had a smooth transition without hardship. Direct observation and discussion with households affected by the change revealed many problems in coping with the situation. Also, it should be stressed that only those households that resettled in the area could be traced and surveyed. Others who left the area may be in a different situation.

Summarized Findings

Very high shares of incremental income in the study households are spent on food. Food expenditures thereby increase almost in parallel with total income. Subsistence orientation is much driven by land availability in the study area. Therefore, a rapid increase in land scarcity puts the desired subsistence orientation of households in a squeeze. Subsistence orientation, however, is a choice in view of risky food and labor market environments, and this orientation toward subsistence food provision is reduced when households have higher capital-asset levels and access to wage employment. An expanded rural wage labor market and a buildup of the asset base of households, or in more general terms, better integrated rural financial markets, would reduce subsistence orientation.

At the household level, preference structures contribute to subsistence orientation in a significant way. Reduced subsistence orientation was found to have a shifting effect on the Engel curve and a decreasing effect on food-energy consumption beyond income and price effects. Transaction costs and income-control issues related to subsistence food appear to be at play. Female-headed households are found to have a higher propensity to spend income on food, holding income constant, and a higher cash-income share earned by women in the households was found to have an incremental effect on food-energy consumption at the household level. Therefore, channeling resources to women may have additional benefits for welfare effects related to food consumption in this setting.

The special case of farmers displaced by tea factories in the study area is found to have a major adverse effect on the households' asset situation. However, due to off-farm employment opportunities and access to crop-cultivation opportunities in forest lands, displaced households identified in the study setting were able to maintain food-energy consumption levels above minimum requirements. The expropriated farmers were pushed into the natural forest and onto the hilltops, which raises production-sustainability concerns.

7

CONSUMPTION-NUTRITION-HEALTH LINKS

A major objective of this research is to trace changes in agricultural production—especially its increased commercialization—via their employment and income effects to effects on consumption and nutrition. The nutritional effects are not only driven by the income-consumption linkages but also, as conceptualized in Figure 2, are affected by the health and sanitation environment of the household.

Structure and Prevalence of Malnutrition among Children

The nutritional status of children between six months and six years of age is evaluated by means of anthropometric measurements, that is, weight and height measurements related to each other and to the age of the child and compared with the standard reference population. As reference population statistics, the World Health Organization-U.S. National Center for Health Statistics (WHO-NCHS) standards were used to identify the prevalence of malnutrition and the nutritional status of individual children. From these variables, indications for more long-term nutritional status problems and short-term malnutrition are derived:

- Height-for-age represents a long-term indicator, as it reflects the past growth of the child, which is the result of numerous factors beginning with birth weight and including morbidity and consumption-deficiency episodes throughout childhood.
- Weight-for-age represents a long-term and, to some extent, a short-term indicator, as it is related to the child's height and the extent of present undernourishment given a certain height.
- Weight-for-height indicates a short-term nutritional situation.

In referring to these conventionally used measures, it is pointed out by Payne (1987) that child growth is not an indicator that enables one to distinguish food deprivation from infection as an initiating event. In acknowledging the limitations (and strengths) of such nutrition indicators for policy and for evaluation, the authors refer to Payne's comprehensive article and the quoted literature therein.

The child population in the survey households was weighed and measured before the initial survey and in each survey round. It was found that in the beginning of 1986, 21.5 percent of children were growth retarded—that is, below 90 percent of the reference height-for-age. About 10 percent of the children were found to be underweight—that is, below 80 percent of the threshold level of weight-for-age. Five percent of them showed symptoms of wasting—that is, their weight-for-height was below 90 percent of reference standards (see Table 41).

The short-term indicator of nutritional staus—weight-for-height—shows substantial change over the survey period: in the presurvey measurements, a much higher percentage of children was found in the category of wasting (11 percent), but this percentage share dropped to about 2 percent precisely one year later in survey round 3. The percentage of children below standard weight-for-height in late 1985 (round 0) is

Table 41—Prevalence of malnutrition among children aged 6-72 months in the sample population, 1985/86

Indicator	Number of Children	Percent of Children[a] Round 0	Round 1	Round 2	Round 3
Below 90 percent height-for-age	181[b]	18.8	21.5	23.2	23.2
	238	...	20.2	22.3	21.8
Below 80 percent weight-for-age	181[b]	11.0	9.9	13.2	8.8
	238	...	10.1	12.6	10.1
Below 90 percent weight-for-height	181[b]	11.0	5.0	3.9	2.2
	238	...	5.5	3.4	2.1

Source: International Food Policy Research Institute survey, 1985/86.
[a]The data for 181 children are taken from a subsample. The same 181 children were surveyed in all rounds. The 238 children include those 181, and the 238 are the same children in all rounds.
[b]These measurements were taken in December 1985.

assumed to be related to the severe drought-induced food shortage in that year and to a dramatic food-price inflation that was partly a result of the local shortage and partly a result of the generally short food supply in the East African region, which also had an impact on food prices in the study area.

Food-Energy Deficiencies and Malnutrition

Levels of nutritional status in comparison with a reference population can be conveniently expressed in terms of Z-score values. A Z-score value of zero indicates a child who is "normal"; a negative Z-score value indicates an anthropometric measurement below the one in the reference population; and a threshold level of below -2 Z-scores is commonly considered an indication of a serious nutritional problem.[14]

In Table 42, Z-score values are presented for the three anthropometric measurements, and these values are broken down by households that consumed less than 80 percent of calorie requirements versus the rest of the households in the three survey rounds. There is a clear indication that children in the households that consume less than 80 percent of the requirements show a worse nutritional status than children in households that consume above the 80 percent cutoff point. The differences are pronounced in the height-for-age and weight-for-age indicators, but not in the weight-for-height indicators. The latter may be a surprise but is explainable: the anthropometric measurements were taken roughly at the same time as the food-consumption levels in the households were surveyed. Effects for short-term weight losses may not be appropriately captured by current food- consumption levels because there are time lags involved. The clear association between nutritional status and calorie deficiency for height-for-age and weight-for-

[14]Z-scores = Actual Measurement - 50th Percentile Standard/Standard Deviation of 50th Percentile Standard.

Table 42—Prevalence of malnutrition among children aged 6-72 months, by household calorie-consumption levels, 1985/86

Round/ Consumption Group	Number of Children	Height-for-Age Average Z-Score	Height-for-Age Below 90 Percent of Standard Median	Weight-for-Age Average Z-Score	Weight-for-Age Below 80 Percent of Standard Median	Weight-for-Height Average Z-Score	Weight-for-Height Below 90 Percent of Standard Median
			(percent)		(percent)		(percent)
Round 1							
Total	238	-1.33	20.2	-0.62	10.1	0.29	5.5
Less than 80 percent of requirements	48	-1.72	27.1	-0.97	18.8	0.11	6.3
Not less than 80 percent of requirements	190	-1.23	18.4	-0.53	7.9	0.34	5.3
Round 2							
Total	238	-1.51	22.3	-0.60	12.6	0.29	3.4
Less than 80 percent of requirements	8	-1.77	26.1	-0.78	15.9	0.21	3.4
Not less than 80 percent of requirements	150	-1.37	20.0	-0.49	10.7	0.33	3.3
Round 3							
Total	238	-1.48	21.8	-0.62	10.0	0.24	2.1
Less than 80 percent of requirements	160	-1.51	23.1	-0.63	10.0	0.24	1.9
Not less than 80 percent of requirements	78	-1.41	19.2	-0.58	10.3	0.22	2.6

Source: International Food Policy Research Institute survey, 1985/86.

age may indicate that households with a more persistent calorie-consumption problem are also the ones in which the retarded and underweight children are found to a larger extent.

This is also reflected in the higher prevalence of malnutrition found among households that have deficiencies below 80 percent of requirements. For instance, in survey round 1, 19 percent of children from households consuming below 80 percent of requirements were found to be seriously underweight, but only 8 percent in the other households (below 80 percent of the standard median weight-for-age). The significance of these apparent differences by calorie-consumption levels has to be evaluated further in the context of the household's health and sanitation environment and demographic structures. This will be done in a multivariate analysis below.

Malnutrition and Commercialization

Before entering into the multivariate analysis, a further exploration of basic patterns of malnutrition and prevalence of malnutrition will be looked at briefly. First, children from households with larger farms show a lower prevalence of growth retardation and underweight (Table 43). Second, there is apparently a strong positive association between increased per capita income approximated by total expenditure per capita, and long-term nutritional status as represented by height-for-age indicators and related

Table 43—Prevalence of malnutrition among children aged 6-72 months, by various socioeconomic and farm-household characteristics, March 1986

Group	Number of Children	Height-for-Age: Average Z-Score	Height-for-Age: Below 90 Percent of Standard Median	Weight-for-Age: Average Z-Score	Weight-for-Age: Below 80 Percent of Standard Median	Weight-for-Height: Average Z-Score	Weight-for-Height: Below 90 Percent of Standard Median
			(percent)		(percent)		(percent)
Total sample	219	-1.49	21.5	-0.60	12.3	0.29	3.7
Farm-size quartiles (average hectares)							
Bottom (0.23)	54	-1.74	29.6	-0.78	14.8	0.28	5.6
Second (0.45)	56	-1.64	25.0	-0.70	14.3	0.28	5.4
Third (0.74)	51	-1.33	13.7	-0.56	9.8	0.34	2.0
Top (1.53)	58	-1.23	17.2	-0.39	10.3	0.28	1.7
Expenditure quartiles (total per capita)							
Bottom	54	-1.75	27.8	-0.65	11.1	0.37	1.9
Second	57	-1.59	21.1	-0.74	17.5	0.23	7.0
Third	54	-1.39	20.4	-0.56	5.6	0.28	1.9
Top	54	-1.22	16.7	-0.46	14.8	0.30	3.7
Subsistence orientation in agricultural production (concept 1)[a]							
Bottom quartile	60	-1.39	23.3	-0.58	13.3	0.27	0.0
Second quartile	49	-1.66	26.5	-0.72	16.3	0.25	4.1
Third quartile	56	-1.36	16.1	-0.60	12.5	0.22	10.7
Top quartile	54	-1.53	20.4	-0.53	7.4	0.44	0.0
Subsistence orientation in consumption (concept 3)[b]							
Bottom quartile	46	-1.70	28.3	-0.70	15.2	0.35	2.2
Second quartile	59	-1.69	22.0	-0.68	15.3	0.37	5.1
Third quartile	57	-1.45	24.6	-0.72	12.3	0.18	5.3
Top quartile	57	-1.14	12.3	-0.34	7.0	0.28	1.8
Households growing tea	37	-1.38	18.9	-0.64	13.5	0.25	2.7
Households not growing tea	182	-1.51	22.0	-0.60	12.1	0.30	3.8
Households with commercial potato field in Gishwati	91	-1.22	16.5	-0.46	9.9	0.31	2.2
Households without commercial potato field in Gishwati	128	-1.68	25.0	-0.71	14.1	0.28	4.7

Source: International Food Policy Research Institute survey, 1985/86.

[a]Value of agricultural produce consumed in the household in percent of production value (concept 1, see Chapter 4).

[b]Own-produced food consumed in percent of total expenditure (concept 3).

prevalence rates of malnutrition. About 28 percent of children in the bottom quartile are found below 90 percent of standard height-for-age, but only 17 percent in the top quartile of per capita expenditure. Much less clear is the association between income and weight-for-age and weight-for-height.

In one section of Table 43, households are grouped by the degree of agricultural subsistence orientation. The bottom quartile represents those households with very little subsistence orientation of their production, while the top quartile represents households that are largely subsistence-oriented (concept 1 of subsistence, as defined in Chapter 4). In none of the three nutrition indicators is a relationship apparent between agricultural subsistence orientation and nutritional status, expressed in either Z-scores or prevalence rates. Of course, numerous other factors require joint attention with the degree of agricultural commercialization, and, therefore, tabulations give only limited insight. Disaggregating the linkages between agricultural production, income, and nutritional outcome is, for that reason, essential to understanding the process.

A broader approach toward the relationship between subsistence orientation in consumption and the nutritional effects is taken with the tabulation in another section of Table 43. Households are arranged by quartiles of degree of subsistence orientation in consumption (concept 3). Comparing the bottom quartile with the top quartile indicates a much-reduced degree of stunting, on average, and a lower prevalence of children below 90 percent of height-for-age (12.3 percent versus 28.3 percent). Not as pronounced but also in the same direction is the impression from the weight-for-age figures, but not the short-term nutritional indicators of weight-for-height, which for the March 1986 survey round (used for Table 43) are at very low levels of prevalence. It should be noted, however, that income is not held constant in this tabulation. As shown earlier, the more subsistence-oriented households tend to have a larger farm-resource base and higher income. Nevertheless, the finding of an apparent positive association between nutritional improvement and higher degrees of subsistence orientation in consumption is in line with the earlier finding from the calorie consumption models, which indicated that an increased degree of subsistence orientation in consumption was associated with an increased level of calorie consumption in that case beyond household income levels. Further evaluation of these effects in multivariate analysis follows below. Especially household-specific demographic factors may be influencing some of these tabulated results, as will be shown below.

Straightforward comparisons of nutritional status in households that are involved in major commercialization activities—that is, growing tea versus not growing tea and cultivating commercial potato fields (in Gishwati) versus not cultivating such fields—are presented at the bottom of Table 43. While no apparent differences show up in the comparisons between tea growers and other farm households, a lower extent of malnutrition prevails in households with commercial potato fields. It should be stressed, however, that having such fields in the Gishwati forest was associated with higher income, both from the fields and even excluding these fields—that is, higher-income households were those that got more access to these new income sources. So this comparison may largely reflect a positive relationship between income and nutritional improvement. The following multivariate analysis sheds further light on this.

Causes of Malnutrition: Multivariate Analysis

The preceding descriptive account of the prevalence of malnutrition has shown that short- and long-term determinants of malnutrition consist of a complex set of interacting variables. It is certainly not only current household-level food availability, for instance, measured in calorie consumption per capita, that determines children's stunting or wasting as assessed in the anthropometric measurements. Interactions between low levels of food consumption and a poor health situation of children reinforce each other and lead to deterioration of nutritional status.

These complexities will be addressed in more detail with the help of a multivariate analysis. This analysis ties in with the conceptual framework outlined in Chapter 4. Changes in levels of food consumption were traced from employment, income, and agricultural production effects. The food-consumption effect, therefore, enters this model analysis. Also, as shown in Figure 2, the health and sanitation environment impinges on the nutritional status of children and is therefore treated as exogenous in this analysis. The objective is to explain differences and short-term changes in children's nutritional status. Height-for-age, weight-for-age, and weight-for-height indicators defined in terms of Z-score values are the dependent variables of the following models presented in Table 44.

It should be noted at the outset that such anthropometric models, which make use of cross-sectional information and short-term-change information over the rather short-term survey period, can only achieve a relatively low level of explanatory power in terms of coefficient of determination (R^2). Quite commonly, R^2 of 0.05 to 0.10 are considered normal or at the higher end for such models. This is so because of numerous factors that cannot be fully captured in such models without a long-term, child-specific data base. Especially important among these factors are the determinants of the long-term growth history of children, which for the elder children is a function of the household food and health environment many years before; children's birth weight, which may be partly a function of the mother's health at the time; specific disease circumstances; and child-specific genetic potentials for growth, which can be only partly approximated by the assessment of the mother's and father's heights (which are actually incorporated into the models below). To the extent that these factors are randomly distributed across the sample, which can be fairly assumed for the most important source of noise in such data—that is, the genetic differences between children—this does not impinge on the robustness of parameter estimates (Balderston et al. 1981).

The three models are specified along a set of hypotheses, and actual field data collection was designed accordingly to generate the variables for this set of models. It was hypothesized that increased calorie consumption at the household level leads also to increased calorie consumption for individual children who capture a certain share of incremental household calories. It was assumed that the nutritional-improvement effect of increased calorie consumption is diminishing at the margin, which means that at higher levels of calorie consumption an incremental calorie has less and less nutritional benefit for the children in the household. These hypotheses are depicted by the CALORIES and the CALORIES SQUARED variables in the model (Table 44).

It was also hypothesized that current levels of sickness (SICK) at the time of the anthropometric measurement have an adverse effect on the medium- and short-term measures of nutritional status, that is, the weight-for-age and weight-for-height indicators. Furthermore, it was specifically hypothesized that children who are infested with intestinal worms (WORMS) are less efficient in making use of incremental food-energy consumption, and therefore are, at given levels of household food consumption, less well-off nutritionally (see Stephenson 1980). A better sanitation environment, as represented by CLEAN TOILET as an indicator variable for sanitation quality, would be expected to improve children's nutritional status.

Household demographic structure, size, and composition and individual child demographics can play an important role in children's nutritional performance. It may be

Table 44—Multivariate analysis of determinants of nutritional status of children aged 6-72 months, 1985/86

	Model 1				Model 2				Model 3			
	Height-for-Age (HAZ)				Weight-for-Age (WAZ)				Weight-for-Height (WHZ)			
Explanatory Variable[a]	Estimated Parameter	t-Value	Mean of Variable	Standard Deviation of Mean	Estimated Parameter	t-Value	Mean of Variable	Standard Deviation of Mean	Estimated Parameter	t-Value	Mean of Variable	Standard Deviation of Mean
CALORIES	1.69E-04	3.50	2,561	1,035	9.36E-05	2.52	2,561	1,035	3.08E-04	2.58	2,578	1,044
CALORIES SQUARED	b	...	...	...	b	...	...	...	-4.88E-08	-2.41	7,732,319	6,112,009
SICK	-4.80E-04	-0.07	3.51	6.87	-0.0182	-3.44	3.51	6.87	-0.0208	-4.64	3.50	6.82
WORMS	-0.2521	-2.68	0.50	0.50	-0.0671	-0.93	0.50	0.50	0.0791	1.30	0.51	0.50
CLEAN TOILET	0.5295	5.55	0.60	0.49	0.2151	2.94	0.60	0.49	b	...	...	
ln CAPITA	1.1396	3.81	1.82	0.31	0.9359	4.08	1.82	0.31	0.3046	1.57	1.82	0.31
BORDER	-0.1356	-2.65	3.34	1.78	-0.1613	-4.12	3.34	1.78	-0.0725	-2.19	3.36	1.75
SEX	-0.3004	-3.18	1.53	0.50	0.2573	-3.56	-1.53	0.50	-0.0722	-1.19	1.54	0.50
AGE	-5.35E-03	-1.99	44.39	20.86	-3.39E-03	-1.65	44.39	20.86	1.19E-03	0.69	43.96	20.95
HEIGHT OF MOTHER	0.0296	3.65	158.13	5.83	0.0169	2.72	158.13	5.83	5.85E-03	1.30	158.16	5.79
HEIGHT OF FATHER	0.0358	3.41	166.65	4.58	0.0199	2.48	166.65	4.58	1.96E-03	0.29	166.60	4.62
Constant	-14.0105	-6.34	...	...	-8.3254	-4.72	...	...	-1.8473	-1.49	...	...
Dependent Variables												
HAZ	...	...	-1.50	1.23	...	...	...	...	...	...	...	...
WAZ	...	...	...	...	...	...	-0.65	0.92	...	...	...	...
WHZ	...	...	...	...	...	...	...	...	...	...	0.26	0.77
$\hat{R}^2$	0.13575				0.09401				0.05643			
F-value	10.78547				7.46429				4.79772			
Degrees of freedom	613				613				613			

[a]Definitions of variables:

CALORIES = calories per adult-equivalent per day.
CALORIES SQUARED = (calories per adult-equivalent per day)^2.
SICK = number of days sick last month.
WORMS = dummy for medium or heavy load of worms in stool examination; 1=positive results, 0=no or low infestation.
CLEAN TOILET = dummy for clean toilet; 1=clean, else=0.
ln CAPITA = logarithm of household size in number of persons.
BORDER = birth order of child; 1=first born, 2=second, and so forth.
SEX = sex of child; 1=male, 0=female.
AGE = age in months at time of anthropometric measurement.
HEIGHT OF MOTHER = height of mother in centimeters.
HEIGHT OF FATHER = height of father in centimeters.

[b]Not in equation.

commonly assumed that in larger households with a high children-women ratio, child-care quality and nurturing activities may suffer; that children at the upper end of the birth order are less well taken care of because of the mother's time constraints; and that in most African rural communities, boys perform less well in nutritional-status terms than girls. Beyond that, age-specific differences are controlled for in the nutritional-status indicators, but it is hypothesized that age differences in the Z-score values, which are already normalized for the age-specific standard deviations, will have only a weak effect for differences in nutritional status.

Height of parents is introduced into the model to capture differences within and between ethnic groups. There is a fair amount of range from the rather tall-growing Tutsi population to the short-growing Twa (pygmy) population in the area. These, however, are the extreme, represented to only a minor extent in the sample, which consists almost entirely of Hutu population. Yet within the same ethnic group, the height of parents, insofar as genetically determined, may have an effect on the height of children.

The dependent variables stem from three points of observation in 1986 from each of the three survey rounds. In survey round 1 (February), only one measurement was taken, and this enters the analysis. In survey rounds 2 (May) and 3 (September), two measurements of children were taken at the beginning and at the end of each round. The mean values of these two measurements are included in the model analysis. Testing has been done for differences specific to survey rounds in the anthropometric measurements besides the explanatory variables just discussed, but no statistical differences have been found beyond the variables actually included in the model.

The results of these multivariate analyses are presented in Table 44. Of the most important results, the following will be highlighted in brief.

As hypothesized, a strong nutritional improvement effect of the incremental food consumption is found, and in the case of the short-term nutrition indicator (WHZ) it is also, as hypothesized, decreasing at the margin. The latter result was not found in models 1 and 2 for the height-for-age and weight-for-age models, respectively, so the CALORIES SQUARED variable was dropped from the model.

To the extent that subsistence orientation had an incremental effect on calorie consumption—as identified in Chapter 6—increased commercialization would somewhat diminish the level of the positive calorie-child growth link. The order of magnitude of this effect, however, is minuscule at the margin and is much overcompensated for by the favorable income effects of commercialization.

The calorie-consumption effect on nutritional improvement is found to be positive and statistically highly significant. The order of magnitude of even the total effect of increased calorie consumption on nutritional improvement, however, is not very high, as becomes clearer in the following computations that make use of the parameter estimates. If household-level calories increased by 10 percent in a household that consumes 2,000 calories per adult-equivalent person, the Z-score value of weight-for-height would increase for children in this household, holding all else constant, by 0.021 (8 percent of the mean value of the sample's weight-for-height). At the same levels of calorie consumption (2,000 per adult-equivalent), a 10 percent increase in calories would improve the Z-score height-for-age value by 0.035 Z-scores (2.3 percent) and the weight-for-age Z-score value by 0.019 (2.9 percent). While these calorie-anthropometry links do not appear large, they are found in this study to be of a much larger magnitude than in two comparable studies in Kenya (Kennedy and Cogill 1987) and in the

Philippines (Bouis and Haddad 1990) and also of somewhat larger magnitude than in a similar study in The Gambia (von Braun, Puetz, and Webb 1989).

Further analysis may be required to explore the effects of diet composition on nutritional-status performance, especially the extent to which increased commercialization of subsistence agriculture changes diet composition. The effects of stable and sustained increases of food-energy consumption on nutritional status, as compared with effects of short-term increases, also need to be explored further. The complex dynamics of the consumption-nutrition linkages could not be fully captured with the short time period covered. Also, the nonlinearity in consumption-nutrition relationships, as identified in the weight-for-height model, may have a more complex structure. It is not unlikely that both of these factors—dynamics of relationships and nonlinearities—may lead to an underestimation of the impact of consumption shortfalls on nutrition. Moreover, energy expenditures are not accounted for. Household-level calories per adult-equivalent person are therefore only a rough approximation of (in-)sufficiency.

The health and sanitation-related variables (SICK, WORMS, CLEAN TOILET) show some interesting and sizable effects. As expected, current underweight (weight-for-height and weight-for-age) is substantially a result of current or recent morbidity or episodes of morbidity. This is not the case for the height-for-age model, which shows a strong effect of worm infestation on the long-term nutritional status of children. The effect is large: for children severely affected by worm infestation (which is the case for half of the child population) this means, holding all else constant, a reduced Z-score value by a quarter of the standard deviation, or in other words, 17 percent of the mean value of the long-term nutritional indicator (HAZ).

Somewhat surprisingly, no significant correlation was found between the three health- and sanitation-related variables. A good sanitation environment, as represented by the CLEAN TOILET variable, has a positive effect beyond the specific morbidity variables (SICK, WORMS). Again, a statistically significant and large impact of improved household sanitation conditions is found for children's nutritional status. A CLEAN TOILET variable should be interpreted as a proxy for more generally improved household-sanitation conditions. The parameter estimate suggests that improved sanitation conditions, in comparison with the poor conditions found in 40 percent of the households, lead to an improvement of about 33 percent in both height-for-age and weight-for-age indicators.

In terms of magnitude, the effects of health and sanitation improvement are certainly much larger than those of overcoming the food-energy deficiency and emphasize the importance of strengthening the rural health system for nutritional improvement. However, it should also be stressed that improving household sanitation and coping with sickness in this environment are not free of charge. Time costs and cash costs for both are considerable, and as shown in the expenditure analysis, the top quartile of households ranked by expenditure per capita spend considerably more than the rest of the population on health care. The approximate income elasticity of health expenditures was 2.28 (Table 29). Increased income, therefore, not only has a nutritional-improvement effect via the food consumption link but also through the health and sanitation link.

Some of the variables related to demography and population growth show interesting results. Contrary to the study hypothesis, an increased household size is found in this sample to be positively related to nutritional improvement and significantly so for the long-term nutritional-status indicator and the medium- to long-term one (HAZ, WAZ).[15] Positive economies of scale in the household economic system may be a reason for this. For example, in a small household of, say, mother and children with husband working off-farm, a sick child brought to the health center would much more affect income earning and child nurturing for the remaining family than in a larger household unit with another caretaker (including an elder child) around.

However, the surprising positive effect of larger household size on anthropmetric status—holding all else constant—must not be misinterpreted as a positive impact of population growth on nutritional-status improvement and thus on poverty alleviation. As argued by Birdsall and Griffin on the impact of rapid population growth on poverty, there is some theory but little hard evidence. "People make decisions about family size in an environment where they are bombarded by a variety of signals, opportunities, and constraints" (Birdsall and Griffin 1988, 50).

The demographic variables related to specific children—that is, birth order, sex, and age of child—all work in the expected direction as hypothesized above. Contrary to the Asian experience, here girls are significantly and substantially better off in terms of nutritional status than are boys. Children of a higher rank in terms of birth order are, all else being equal, significantly worse off. This is so although the study controls for age of child and has an age-normalized dependent variable. There clearly seems to be an increased marginalization of the incremental child. This probably relates to the mother's capacity for child-nurturing activities. Finally, it is confirmed that parents' height has a significant effect on children's height-for-age and weight-for-age. While these parental variables improve the explanatory power of the models, they were found to have no significant effect on the parameter estimates for the remaining variables.

Summarized Findings

The results of this analysis underscore the fact that malnutrition in this environment is to a very large extent a health problem that needs to be addressed by the health and sanitation services.

Household food-consumption levels are, of course, important but do not dominate the nutrition problem as measured by children's growth performance. Both the food-consumption and health-related determinants of nutrition can be stimulated toward growth and nutritional improvement through income linkages and provision of rural services. Specialization and commercialization of agriculture with improved market integration can be part of this process to the extent that it generates increased real income and employment for the poor. Clearly, a narrow focus on food production alone, with a food self-sufficiency concept for the household in mind, will not be sufficient for nutritional improvement if it does not lead to rapid income growth. The less that rapid growth of real per capita income can be stimulated in this area with increasingly limited production resources, the more important is delivery of effective and efficient health and sanitation services to contribute their potential for nutritional improvement.

While the consumption analysis in Chapter 6 showed that increased subsistence orientation has a beneficial effect for household calorie consumption beyond a given

[15]This is contrary to what is found in a similar analysis for households in rural Gambia, where, however, households are on average three times as large as in this sample (see von Braun, Puetz, and Webb 1989).

income level, the nutrition-related analysis in this chapter points at a very marginal effect that this calorie-consumption effect of subsistence orientation may have on nutritional status and suggests that this marginal effect is much overcompensated for by the favorable income effects of commercialization. Improvement of health and sanitation is key to rapid improvement of child welfare. Clean toilets, diarrhea control, and cures for intestinal worms—all low-cost measures—have a large impact on child growth performance in this setting.

Of special concern are the households pushed into the most marginal areas in the process of population growth and increasing scarcity of land resources. For these long-term developments in the area—which are of direct and indirect importance for sustainability of rural life and, in that context, for the health and nutrition of children—rapid expansion of improved agricultural production practices and new technology is required. This issue is addressed in the next chapter.

8

LONG-RUN PERSPECTIVES FOR RURAL DEVELOPMENT

So far, the impact of commercialization on production and employment has been discussed within a framework of comparative static analysis. Yet, the socioeconomic conditions and relationships that were found in the survey may change over time because of the dynamic impacts of population growth, investment and disinvestment, technical change, and social differentiation.

This chapter will concentrate on two aspects of the development process that seem to be of crucial relevance for long-run changes in the socioeconomic situation of rural households, the carrying capacity of the regional economy, and thus, indirectly, the access of the rural population to food. One of these aspects concerns further social differentiation that might result from unequal scope and pace of participation in market integration among rural households. It is at least hypothetically conceivable that this might cause an increasing differentiation in terms of capital accumulation and thus favor an uneven distribution of incomes. Such tendencies are of particular interest as they affect changes in the distribution of farm sizes.

The other aspect relates to the envisaged impact of population growth on the further prospects of commercialization. Subsistence requirements of a growing rural population and economic interests in commercialization of farm produce compete for scarce resources, namely, land. As the population continues to grow, the households' marketable surplus may tend to shrink in favor of subsistence production. The change in factor proportions—the rise in person-land ratios in particular—may also initiate changes in technology and labor use. The outcome of this may be not only an intensification of farm labor input but also a growing "commercialization of labor" via off-farm work. These envisaged adjustments at the household level have considerable implications for the regional economy that will be discussed on the basis of long-run simulations in the last part of this chapter.

Changes in Farm-Size Structure via the Land Market

It was argued by several authors in the 1970s that one of the long-run effects of increasing commercialization of semisubsistence agriculture might be the favoring of a social differentiation among rural households (see, for example, Griffin 1974 and Jacoby 1971). The basic argument underlying this hypothesis is that in the process of commercialization, those households that enter the market economy earlier than others gain an advanced position in terms of capital accumulation and resulting income flows. Their level of cash income is raised because of an increasing specialization and participation in the exchange economy. These farmers would reinvest their cash profits in order to further increase their resource base. In the absence of productive investment opportunities outside the agricultural sector and in the expectation of increased prices of land and agricultural commodities, it is likely that such investment would concentrate to a certain extent on farmland.

When there are no legal constraints on the land market—for example, the restriction or even complete prohibition against selling and buying farmland, as found in many agrarian societies where communal landownership predominates and no private ownership exists—this might lead to a concentration of farmland. The resulting inequality of distribution of landownership and access to farmland is further aggravated when it is the resource-poor farmers, in particular, who sell farmland or parts of it in order to meet immediate cash requirements in stress situations when the income flow is interrupted—for instance, in a drought or when sudden high expenses are incurred for health care.

Transactions of farmland via the purchase market have indeed played a role in Rwanda, and in the study area in particular. On average, farmers in the sample had acquired 20 percent of their land by purchase.

However, both the number of transactions per year and the volume of farmland transferred in the study area has declined drastically in recent years. According to the land registry office of Giciye *commune*, the number of farmland transactions has varied from 1 to 6 per year since 1977, while the number of transactions registered between 1965 and 1976 varied from approximately 40 to 135 transactions per year. This tendency is confirmed by results of the IFPRI survey (subsample). This decline in transactions accompanied a rapid increase in land prices.

The Rwandan government makes legal interventions in the land-purchase market. These interventions aim to prevent social differentiation by controlling access to the land market through prohibition of farmland purchases by households that already have 2 or more hectares and of land sales by those who have only 0.5 hectare or less (Buschmann 1985). As a consequence, the possibility of getting at least temporary access to farmland via cash rental arrangements has gained importance. In 1985/86 the average share of land rented for cash in total farm size was 16.6 percent in the survey households. As the rent normally has to be paid in advance, those farmers are favored who have higher cash liquidity and who can even afford to pay in advance for several seasons to ensure a medium- to long-term right of use.

Coming back to the original hypothesis concerning an impact of increasing commercialization on social differentiation and land concentration, the subsample survey results do not show that farmers with higher degrees of commercialization in agricultural production are more engaged in farmland acquisition than others (further details can be found in Blanken 1989).

A special case is commercial potato production in Gishwati. The survey results indicate that access to Gishwati land is not evenly distributed among all sample households and that the respective size of Gishwati land varies considerably within the sample. There are indications that given the high land prices on the purchase market, which can almost be considered prohibitive for any further transactions, investment has shifted to potato production in the Gishwati area.

Commercialization and Population Pressure—A Simulation Model

The following is an attempt to simulate the aforementioned second important feature of the long-run development process—namely, the effect of rising population pressure on allocation of farm resources (that is, land and labor) between subsistence needs, marketing of products, and off-farm labor supply.

Theoretical Background

Observations of farmers' behavior in economic environments such as this suggest that security of subsistence typically has top priority in production decisions. This implies that available land is allocated to crops that serve for home consumption—if land availability permits—until a desired degree of subsistence is reached. This behavior is driven by risks and uncertainties in the food and off-farm labor market and by an undeveloped capital market. As the farm population grows, more land is required for subsistence, first to the detriment of remaining fallow, but later also at the cost of marketable surpluses. Thus the rapid population growth in the region may impose a limit to commercialization of agricultural production. This limit might appear even sooner if the reduction of fallow periods happens to have a negative impact on soil fertility and yields.

Evidently, this decline of marketable surplus and the fallback into subsistence may be slowed down or even totally avoided by means of agricultural investment and technical innovation. The introduction of land-saving technologies will certainly be of paramount importance in the years to come. Yet chances for high rates of technical progress during the immediate future are rather small. Innovations with low external inputs do not so far appear promising under the conditions of smallholder agriculture in the region. There is some scope for erosion control and agroforestry systems, some of which are quite promising but have so far proven to be difficult to implement. The survey indicates that, as person-land ratios grow, farmers tend to intensify the labor input per hectare, enabling them to increase crop yields and to reduce the decline in per capita subsistence production that accompanies population growth. Significant and sustainable rates of productivity increase, however, will require a rising use of external inputs, particularly new seeds and mineral fertilizer. This need, however, imposes a problem because the purchase of external inputs requires the availability of cash, which is more and more constrained by the decline of marketable surpluses.

Given these limits to an acceleration of growth in agricultural production, it is evident that nonagricultural employment gains more and more importance. Theories of farm households suggest that such activities become more attractive as limited farm resources cause the agricultural marginal-value product to decline relative to nonagricultural income opportunities (see, for example, Nakajima 1970 and Singh, Squire, and Strauss 1986). The results of the survey tend to support these theories: households with larger person-land ratios spend a significantly higher share of their total labor capacity on nonagricultural activities, partly (women) in home production for sorghum beer brewing and partly (men) in off-farm employment. Hence, as a result of ongoing population growth and land scarcity, farm households do not seem to fall back into a noncommercialized state. They rather shift the emphasis from the marketing of agricultural produce to the commercialization of parts of their labor force. They tend to develop toward mixed employment patterns.

In principle, this emerging structure of rural households holding multiple occupations in on-farm and off-farm employment would certainly provide rather good opportunities for a sustainable regional economic development. The nutritional requirements would have to be increasingly met by purchasing food out of incomes earned in nonagricultural employment. Whether or not and to what extent such a change can be realized, and whether this will facilitate the nutritional situation, will depend on the availability of sufficient employment opportunities, on the propensity to spend the resulting income on food, and finally on the real price of food and the wage rate.

The simulation model presented subsequently is an attempt to generate a rough quantitative estimate of the future dimension of this development challenge. It is strictly confined to the sample households; it does not simulate the overall regional development. It is concerned with the prospects for the long-run development of the production systems, the marketable surplus of agricultural products, and the potential supply of labor. It does not address itself to the market for agricultural products or to the regional demand for nonagricultural labor.

The model consists of two components. One is a demographic component that projects future demographic change based on the current age structure of the sample population and observed demographic variables (fertility, mortality). The other is a resource allocation and production component that describes the likely response of land use systems, production, and labor use to the population pressure projected by the demographic component. The consequences of technical change going beyond the impact of intensified labor use due to population growth are analyzed in a second scenario.

The Demographic Component

Continuing high rates of population growth are seen to be the most important factor to bring about changes in the farming systems prevailing in the study area.

The demographic model assumes that neither immigration nor emigration will occur in the area represented by the sample households during the simulation period and that the land basis observed in 1985 will not change during the next two decades.[16]

Following are the major results of the demographic forecast. If the demographic parameters[17] observed during the period 1978-83 were to continue for the next two decades, the total sample population would more than double. This corresponds to an average annual growth rate of 4.1 percent for the period 1985-95 and 3.9 percent for 1985-2005.[18] The distribution of the total sample population by different age groups does not change much given current parameters (Table 45).

The average person-land ratio increases from 5.51 in 1985 to12.01 in 2005.[19] The resulting rate of growth (4.0 percent a year) is slightly higher than the average annual

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[16]This assumption also means that the absolute amount of land in the Gishwati area will remain constant for those households and their offspring who had access in 1985/86, while those households that did not have any Gishwati land will not have any in future years.

[17]The relevant demographic parameters for the model have been taken from different sources. The birth rates of five-year-old cohorts were taken for Gisenyi *prefecture*. A sex ratio at birth of 100 is assumed for the purpose of the model. The detailed birth rates by age groups are shown in Appendix 2, Table 54. While detailed information on the sex and age cohort-specific mortality rates are available on a national level for infants of different groups below four years of age only, no official mortality rates could be found for children and adults of both sexes.Therefore, the sex and age cohort-specific mortality rates have been computed from the sex and age distribution of the total Rwandan population according to the official censuses of 1978 and 1983. The detailed death rates by sex and age groups are shown in Appendix 2, Table 55.

[18]According to the communal censuses of 1978 and 1983, the average population growth was 4.2 percent a year for Giciye *commune*.

[19]The person-land ratio is defined as the number of adult-equivalent persons per hectare (see Appendix 2, Table 56 for coefficients used to calculate the number of adult-equivalent persons).

Table 45—Shares of different age groups in total sample population, 1985-2005

Age Group	1985	1995	2005
Below 15 years	49.2	50.5	49.4
15-55 years	43.8	42.2	43.1
Above 55 years	7.0	7.3	7.5

Source: Authors' model projections.

population growth rate of 3.9 percent. The average consumer-worker ratio will remain largely unchanged.[20]

Table 46 contains these household characteristics broken down by person-land-ratio quartiles. This shows that for the highest person-land-ratio quartile, the person-land ratio will more than double from the already high level, while the increase is less dramatic in the lowest person-land-ratio quartile. The table further reveals that, in terms of the consumer-worker ratio, workers of households in the highest quartile have to support fewer household consumers; this will remain the same for quite some time.

In 1985, 23.4 percent of the population fell in the group of the top person-land-ratio quartile (least amount of land), but 20 years later, 74.8 percent of the population will be in that class (Table 47). Of course, these are not predictions, but status quo extrapolations indicating which agrarian structure will exist in the future if current fertility and mortality rates continue and if the nonagricultural economy within or outside the region does not absorb more of the farm population than in the past.

The Resource Allocation and Production Component

It has already been shown that the allocation of land to the various crops and cropping systems highly depends on both the altitude and the person-land ratio of the households. From this observation, a dynamic simulation model is derived that analyzes the effects of the demographic development on adjustment processes in the farming systems that might take place in the future.

Table 46—Person-land ratio and consumer-worker ratio, 1985-2005

				Lowest and Highest Person-Land-Ratio Quartile					
	Sample Average			1985		1995		2005	
Ratio	1985	1995	2005	Low	High	Low	High	Low	High
Person-land ratio[a]	5.51	7.93	12.01	1.97	10.87	2.68	15.76	3.72	23.94
Consumer-worker ratio[b]	1.28	1.33	1.28	1.36	1.18	1.40	1.28	1.33	1.24

Source: Authors' model projections.

[a]Adult-equivalent persons per hectare.

[b]Consumer-equivalents per adult-equivalent person.

[20]The consumer-worker ratio has been calculated by dividing the number of consumer-equivalents by the number of adult-equivalent persons. The number of consumer-equivalents per household has been computed by using the coefficients given by Matlon (1982). (See also Appendix 2, Table 57.)

Table 47—Distribution of sample population by person-land-ratio quartiles, 1985-2005

Person-Land-Ratio Quartile[a]	Share of Households, 1985	Percent of Population in Person-Land-Ratio Quartiles (Total Sample)				
		Share of Population				
		1985	1990	1995	2000	2005
Less than 2.84	25.0	21.7	16.4	8.5	5.5	3.5
2.85-4.44	25.0	27.1	16.8	15.4	10.7	7.2
4.45-6.85	25.0	27.8	30.2	22.5	18.4	14.5
More than 6.85	25.0	23.4	36.6	53.6	65.4	74.8
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: Authors' model projections.
[a]Adult-equivalent persons per hectare.

It is assumed, however, that all subsystems to be found at the end of the simulation period already exist in the base year 1985/86. Again, the results indicate a status quo extrapolation, which indicates the scope of future production that seems realistically conceivable if no fundamental changes are introduced exogenously. In a first step, the cropping patterns of different altitude and person-land-ratio groups have been calculated from the subsample households, taking only the most important crops and cropping systems into account.

Table 48 summarizes the cropping patterns of six subsystems that have been identified. Increasing person-land ratios due to population growth cause households to shift from one subsystem to another, that is, to increase the share of labor-intensive crops, such as sweet potatoes, and the index of cropping intensity. The simulation model captures this effect. As farm households move into another person-land-ratio group, they reallocate their agricultural land and adopt the cropping patterns of the new person-land-ratio group.

It is further taken into account that input use is also adjusted accordingly as the person-land ratio changes. The survey results suggest that this applies primarily to the intensification of the labor input per hectare. Therefore, in the next step of the simulation, the total agricultural labor input per hectare has to be determined. Regression analysis revealed that the person-land ratio is the most significant variable in explaining differences in total labor input per hectare. The following semilogarithmic equation was chosen to depict this population-labor input relationship:

$$TDHA = 98.661 + 352.435 \ln PLR; \quad (t = 6.44) \qquad (10)$$

F-value = 41.5, R^2 = 0.549,

where TDHA is the total labor input per hectare and lnPLR is the logarithm of the person-land ratio.

Output is also expected to change with increased labor inputs per unit of land in the different crops. It is assumed that yields correspond to the respective person-land-ratio

Table 48—Shares of different crops and cropping systems in total farm size, yields, and labor use, by altitude and person-land-ratio group, 1985

Item	Altitude 1 (Below 2,300 meters)			Altitude 2 (Above 2,300 meters)		
	Ratio Group 1	Ratio Group 2	Ratio Group 3	Ratio Group 1	Ratio Group 2	Ratio Group 3
Area shares (percent)						
Maize, sole stand	7.5	12.7	9.2	6.7	6.1	20.4
Maize, mixed	13.5	10.6	9.2	26.3	20.8	33.9
Sorghum, mixed	22.0	20.1	26.1	6.5	10.3	15.0
Sweet potatoes	14.7	22.9	31.3	0.9	7.4	15.9
Beans, sole stand and mixed	3.8	11.6	14.5	0.4	3.8	3.3
Peas, sole stand and mixed	9.0	10.2	7.5	38.9	20.8	7.4
Index of cropping intensity[a]	45.6	55.0	61.9	43.8	40.8	56.4
Yields/hectare (kilograms)						
Maize, sole stand	763	1,131	1,217	763	1,131	1,217
Maize, mixed[b]	4,883	3,860	2,609	4,883	3,860	2,609
Sorghum[b]	3,090	3,626	4,218	3,090	3,626	4,218
Beans	891	1,090	967	891	1,090	967
Peas	412	409	628	412	409	628
Sweet potatoes	4,500	5,200	6,000	4,500	5,200	6,000
Potatoes	9,782	7,573	7,244	9,782	7,573	7,244
Labor use						
Person-days/hectare/year[c]	214	270	445	223	285	305
Family (percent of total)	63	70	88	67	78	81
Nonfamily (percent of total)	37	30	12	33	22	19
Reciprocal exchange (percent of nonfamily)	72	78	93	55	78	81

Source: International Food Policy Research Institute survey subsample, 1986.

Note: The person-land-ratio group is derived from total farm size, including Gishwati; ratio group 1 denotes the lower tercile and ratio group 3 the upper tercile of the households in each altitude group.

[a]Cropland use is aggregated on the basis of the respective crop's area share and duration of growing on the land (in fractions of 12 months).

[b]In megajoules per hectare.

[c]Adult-equivalent persons per hectare.

group in the base year. The model simulates yields changing according to present observation as a farm moves to another person-land-ratio group. The respective yields of 1985/86 are shown in Table 48. In general, yields increase with rising person-land ratios for potatoes and maize-beans-potatoes, but the average yields are considerably lower for the higher person-land-ratio groups. One explanation for this might be that commercial potato production, in particular, requires high cash expenditures for seeds and fungicides, and to a lesser extent for wage labor. Thus, farmers with higher income and higher cash liquidity are favored, and input intensity with seeds and fungicides is probably higher for the more land-rich group. The same holds for maize-beans-potatoes, where often—due to liquidity constraints at sowing time—a plant density could be observed that was suboptimal from an agronomic point of view. This may be a case where yield-increasing labor supply effects (Boserup effects) are constrained by farmers' inability to finance external inputs (Boserup 1981).

Impact of Increasing Population Pressure on Labor Use and Production

In this section the results obtained by the model projections for 1985/86 will be used as the base year when the development of food production is analyzed.

Two different scenarios are distinguished: while scenario 1 is exclusively based on the endogenous changes in agricultural labor input, overall land-use intensity, and changes in the cropping patterns as described so far, technological change effects at constant overall labor-input levels are assumed in scenario 2. As improved varieties were already available in 1985/86, the yields of beans, peas, potatoes, and sweet potatoes (all in sole cropping) are projected to increase by 2.75 percent a year, which implies an increase of 50 percent by the year 2000. This is a rather optimistic assumption. According to Delepierre (1985), on a national level the yields of sweet potatoes and potatoes increased during 1966-83 by an average of 1.6 percent and 0.4 percent a year, respectively, and they are projected to increase further by 1.8 and 0.4 percent a year, respectively, during 1983-2000. On the other hand, the yields of the legumes under consideration dropped by 0.6 percent a year (beans) and by 0.1 percent a year (peas) during the same period. Legume yields are projected to decrease further by 0.8 percent a year (beans) and 0.1 percent a year (peas) until 2000. When projecting the yield development of the four crops, Delepierre assumes a more widespread adoption of improved varieties in the future, but emphasizes that—due to the further reduction of fallow periods and the cultivation of marginal land in the process of continuing population growth—the higher yield potential of the new varieties might not be fully used, and that these new varieties might only partly compensate for the loss in soil fertility.

No improved varieties of maize and sorghum exist for the higher-altitude regions of Rwanda and are very unlikely to be available in the near future. Therefore, the projected increase in the average yields of maize and sorghum is due only to the intensification of agricultural labor input, with no differences between the two scenarios.[21]

Table 49 summarizes the model projections for the production of major crops and total calorie production per consumer-equivalent for 1985-2005. The total calorie production per consumer-equivalent is shown for total farm sizes including Gishwati land (commercial potatoes) on the one hand, and excluding Gishwati land on the other.

In scenario 1, production will increase for maize (+8 percent), sorghum (+24 percent), beans (+12 percent), and sweet potatoes (+40 percent), and decline for peas (-18 percent) and potatoes (-8 percent). In scenario 2, production will increase for all crops, but most rapidly for sweet potatoes and beans.

Looking at the overall calorie supply from own production, Table 49 shows that in scenario 1, calorie production (with farm size including Gishwati) will increase by 11 percent, with a growth rate of 0.5 percent a year. Total calorie production without Gishwati will be increased by 17 percent in the year 2005. This corresponds to an average annual increase of 0.8 percent.

In scenario 2, the average total calorie production will increase 31 percent by the year 2005 when total farm size with Gishwati is taken. This corresponds to an average increase of 1.4 percent a year.Calorie availability from own production per consumer-equivalent and per year will drop by 44 percent in scenario 1 (or by 39 percent for total farm size without Gishwati), and in scenario 2 it will decline by 34 and 30 percent, respectively.

[21]Following Delepierre (1985), the average yields of maize and sorghum are projected to remain more or less unchanged until the year 2000.

Table 49—Average production of major crops and total calorie production, 1985-2005

Item	Scenario 1[a] 1985	1995	2005	Scenario 2[b] 1985	1995	2005
	(index: 1985 = 100)					
Development of production						
Maize	100	106	108	100	106	108
Sorghum	100	116	124	100	116	124
Beans	100	106	112	100	126	148
Peas	100	89	82	100	116	122
Potatoes	100	96	92	100	122	132
Sweet potatoes	100	125	140	100	164	210
Total calorie production (including Gishwati)	100	107	111	100	127	131
Total calorie production (without Gishwati)	100	111	117	100	127	134
Total calorie production per consumer-equivalent (including Gishwati)	100	73	56	100	86	66
Total calorie production per consumer-equivalent (without Gishwati)	100	78	61	100	88	70

Source: Authors' model projections.

[a]Projections based on endogenous changes in labor intensity and cropping patterns, but not on other technological changes.

[b]Like scenario 1, but with additional technological change for beans, peas, potatoes, and sweet potatoes (2.75 percent a year).

In Table 50, indicators of agricultural labor input, production of major crops, and total calorie production per consumer-equivalent are broken down by the top and bottom person-land-ratio quartiles. Although land productivity in terms of calorie production per hectare and per year is substantially higher (approximately 55 percent) for the top person-land-ratio quartile than it is for the bottom quartile, the table shows that calorie production per consumer-equivalent will decline more drastically for the top quartile in both scenarios (by 2005 to 41 percent and 49 percent, respectively, of the 1985 level).

In both scenarios the average yields of maize in sole stands and of sorghum in intercropping would grow at a rate of 0.4 and 0.3 percent a year, respectively, while the average yield of the maize intercropping system would decline by 1.0 percent a year. For the other crops, only minor changes would occur during the simulation period, with an average yield increase of 0.6 percent a year for peas and 0.3 percent a year for sweet potatoes, and an annual decrease of 0.3 percent for potatoes.

The highest relative increases of crop area would occur for sweet potatoes (+ 32 percent) and for beans (+ 29 percent). On the other hand, the total area devoted to peas would drop by 28 percent during the simulation period.

Changes in the composition of total calorie production by the different crops are more or less negligible for the sample averages and the top person-land-ratio quartile. However, considerable change can be expected even under scenario 1 for the bottom person-land-ratio quartile, which includes the currently more land-rich households. The shares of sweet potatoes will increase substantially in both scenarios in this group, while the contrary applies to the shares of potatoes and peas. Thus the reallocation of the

Table 50—Average agricultural labor input, production of major crops, and total calorie production per consumer-equivalent, by person-land-ratio quartiles, 1985-2005

Item	Scenario 1[a]						Scenario 2[b]					
	1985		1995		2005		1985		1995		2005	
	Bottom Quartile	Top Quartile	Bottom Quartile	Top Quartile	Bottom Quartile	Top Quartile	Bottom Quartile	Top Quartile	Bottom Quartile	Top Quartile	Bottom Quartile	Top Quartile
	(index: 1985=100 if not otherwise stated)											
Total agricultural labor input per hectare	100	100	108	102	129	100	100	100	108	102	129	100
Production												
Maize	100	100	106	100	106	96	100	100	106	100	106	96
Sorghum	100	100	119	113	144	106	100	100	119	113	144	106
Beans	100	100	124	112	138	106	100	100	140	140	162	129
Peas	100	100	91	103	74	100	100	100	119	138	98	131
Potatoes	100	100	95	86	84	79	100	100	121	108	108	99
Sweet potatoes	100	100	164	113	259	106	100	100	216	148	339	139
Total calorie production (including Gishwati)	100	100	105	106	108	99	100	100	126	125	130	117
Total calorie production (without Gishwati)	100	100	114	109	127	102	100	100	127	127	144	119
Total calorie production per consumer-equivalent (including Gishwati)	100	100	74	63	60	41	100	100	87	74	70	49
Total calorie production per consumer-equivalent (without Gishwati)	100	100	84	64	78	43	100	100	93	74	88	49
Farm size (including Gishwati, hectares)	1.38	0.29	1.41	0.31	1.36	0.29	1.38	0.29	1.41	0.31	1.36	0.29
Land productivity (calories/hectare)	100	100	102	100	113	99	100	100	121	119	133	117
Labor productivity (calories/person-day)	100	100	96	98	89	99	100	100	113	116	105	117

Source: Authors' model projections.

[a]Projections based on endogenous changes in labor intensity and cropping patterns, but not on other technological changes.

[b]Like scenario 1, but with additional technological change for beans, peas, potatoes, and sweet potatoes.

available farm land brought about by increasing person-land ratios would lead to higher shares of calorie-dense crops such as sweet potatoes, in particular, and to lower shares of protein-rich crops such as peas and beans.

The development of the labor force available on the household level, the labor input for agricultural work, and (computed as a residual) the potential nonagricultural labor supply in person-days per household and per year are shown in Table 51. The labor force of the sample population increases by 111 percent (3.8 percent a year) during 1985-2005. On the other hand, the agricultural labor input, as derived from model scenario 1, increases by only 21 percent over the 20-year period (1.0 percent a year). As a result, the potential nonagricultural labor supply increases during the simulation period by 4.5 percent a year and, consequently, agriculture's share in the total potential labor force use decreases from 23 to 14 percent.

Hence, while the model predicts an additional labor input of 42 person-days per household (1985 basis) for intensified agricultural labor use, this will absorb only 2.3 percent of the expected increment in the total labor force. Approximately 98 percent of the incremental labor would have to be employed in nonagricultural work—possibly to some extent in home production, but primarily off-farm. Even if the assumed incremental labor supply based on the demographic simulation and the assumed 300 days of work per year per person-equivalent would be somewhat on the high side, this result certainly indicates a great challenge for regional development. Of course, the actual supply of nonagricultural, including home-based, labor might be rather different if the agricultural incomes or nonagricultural income opportunities, or both, should deviate significantly from past trends.

Since women will have a high share in the additional demand for nonagricultural employment, and since social as well as cultural factors tend to limit the scope for off-farm work of women, it will be necessary to create particular new employment opportunities for them in home production and off-farm.

The right-hand part of Table 51 shows the development of the same variables, broken down by person-land-ratio quartiles. As might be expected, the possibility of absorbing the additional labor force by intensifying the agricultural labor input is much more restricted in the top quartile. Consequently, the absolute amount of potential nonagricultural labor supply in person-days per year is much higher in this group.

In the mid-1980s the majority of households were not fully meeting their food-energy requirements out of own food production (86.9 percent, Table 52). As long as other income from agriculture and nonagriculture ensures entitlement to food, a further increase in the share of the population dependent on market supplies is not necessarily a problem. According to both scenarios, the degree of required integration into the food market when land becomes scarcer is expected to be quite high. Average household-level self-sufficiency—expressed in terms of percent of own-produced food energy relative to requirements—would drop until 2005 from 73.8 percent to 37.9 percent in scenario 1 and to 44.8 percent in scenario 2 (with additional technological change). The need for imports into the region thus increases substantially, but whether this need will be backed up by effective demand again depends much on employment generation in agriculture and off-farm as well as on prices and wage-rate development. To create this growth in effective demand, especially in those households that are food-deficit at the outset, remains the main challenge for food security policy.

Table 51—On- and off-farm labor allocation and distribution, by person-land-ratio quartiles, 1985-2005

Item	Per Household, 1985	Total Survey Population 1985	1995[a]	2005[a]	Survey Population Quartiles 1995[a] Bottom Quartile	1995[a] Top Quartile	2005[a] Bottom Quartile	2005[a] Top Quartile
	(person-days/ year)			(index: 1985=100)				
Potential labor force capacity[b]	856 (1.00)	100	144 (1.00)	211 (1.00)	100 (1.00)	155 (1.00)	189 (1.00)	223 (1.00)
Agricultural labor input	201 (0.23)	100	112 (0.18)	121 (0.14)	111 (0.30)	109 (0.09)	131 (0.26)	102 (0.06)
Potential nonagricultural labor supply[c] (per household in 1985, and change for total population thereafter)	655[d] (0.77)	100	154 (0.82)	239 (0.86)	155 (0.70)	161 (0.91)	220 (0.74)	239 (0.94)

Source: Authors' model projections.

Note: Figures in parentheses are the shares of the different labor input categories in the potential labor force capacity (first row).

[a]The 1995 and 2005 figures represent the labor supply of the households and their offspring in 1985 sample household averages.

[b]Computed from adult-equivalent persons times 300 days per year.

[c]Including home goods production, such as beer brewing.

[d]It should be noted that this residual potential nonagricultural labor supply includes actual off-farm employment and unemployment time. On average, 96 days of actual employment per household were recorded in 1985 (66 days in the bottom quartile and 88 in the top quartile).

Table 52—Development of overall food-energy production in relation to minimum requirements at household level, 1985-2005

Item	Scenario	1985	1995	2005
Own food production in percent of requirements of households[a]	1	73.8	53.2	37.9
	2	73.8	62.9	44.8
Population not meeting food energy requirements directly out of own production in percent of total population	1	86.9	92.4	95.1
	2	86.9	90.6	93.5

Source: Authors' simulation results.

[a]Requirements are based on the same energy needs as computed in the food consumption analysis in Chapter 6 (2,798 calories per adult-equivalent person).

Conclusions from Long-run Simulations

The specific conclusions derived from the analysis of long-run implications of commercialization may be summarized as follows. The majority of farm households in the study region are extremely resource-poor. Taking into account that the farm population will most likely continue to grow at an annual rate of 4 percent, prospects for commercialization through growing more crops for the market are small. The only exception is the special case of potato marketing out of the Gishwati forest. Even if farmers were able to raise their production through further specialization according to comparative advantages, the general tendency of an increasing overall deficit in food would not change. The rural households will more and more depend on food imports from outside the region.

The hypothesis that yields would tend to decline because of the reduction of fallow could not be explicitly supported out of the survey results. Yet, further observations suggest that the projected rates of yield increase resulting from intensified labor input and improved seed and other inputs are indeed rather optimistic. This is indicated not only by the expectation that the overall rate of land use will be further raised, but also because the consequences of past changes in land use (cultivation on steep slopes and reduction of fallow periods) may materialize only in the future, implying a lagged response. However, in relation to the theme of this study, it has to be reemphasized that such negative prospects for soil fertility are not expected to result from increased commercialization but rather from growing population pressure and resulting subsistence needs and lack of improved production technology. This makes it even more urgent to accelerate the development and diffusion of appropriate innovations by research, extension, and market infrastructure. High-priority measures of land conservation would also be needed.

Rapid expansion of sustainable nonagricultural employment opportunities will be the most important precondition for successful socioeconomic development of the region. The survey has revealed that the farm population already spends 50 percent of its total work time on nonagricultural activities, of which one-half is off-farm work. Since a substantial part of the labor capacity appears to be seasonally or even permanently underemployed, this commercialization of family labor could even currently be raised if more jobs were available. The long-run simulations for the next 20 years have shown that the number of nonagricultural jobs will have to be raised to at least twice as high as in 1985 to even maintain current levels of employment. Not only food purchases but also external inputs for agricultural production will have to be paid for out of off-farm incomes.

Currently, nonagricultural employment depends to a considerable degree on jobs that are offered by a few employers, some of which are not established on a long-term basis. One-third of the time worked off-farm by members of the survey households took place in two donor-financed development projects. Another third was spent at the two tea factories that are currently expanding their operations but have been shown to be in a critical economic situation. Thus only one-third of the nonagricultural work is done in a multiplicity of rural activities, partly self-employment in the rural services, partly in government employment. Future policy support of rural employment will have to be much more concerned with this section of the regional labor market. This is not only desirable in order to support the envisaged commercialization of the rural labor force but also to ensure sufficient supplies of local goods and services and thus support rural growth.

9

CONCLUSIONS AND POLICY IMPLICATIONS

This study's focus is on the potentials and constraints of commercialization and technological change for poverty alleviation in an area under severe population pressure. The prevalence of underconsumption and malnutrition is found to be high and persistent in the study area. Land is becoming extremely scarce. Providing for household food security through subsistence food production is less and less a viable option for the majority of households.

Rapid population growth can be a dominating factor in creating and aggravating rural poverty. As Mellor and Desai (1985) point out, "population growth has this deleterious effect through added pressure on employment opportunities which reduce the income flow to labor and through the upward pressure on food prices derived from the additional demand arising from larger population." These basic effects are particularly strong in Rwanda, where little opportunity to reduce population pressure by out-migration exists and where food markets of the landlocked country are volatile and thin due to high transaction costs. Effective policies to reduce population growth are therefore of paramount importance. An accelerated rate of technological change in agriculture to mitigate the income-depressing effect of the high population growth would not, under optimistic assumptions, maintain even the current levels of poverty. Population growth itself needs to be reduced quickly. The required specific actions in education and health services policies are, by now, well understood and are not the focus of this study.

A high prevalence of underconsumption in average years and the 1984 and 1990 famines in Rwanda underscore the severity of the food security problem. Households in rural Rwanda attempt to achieve food security largely by high levels of subsistence production. On average, two-thirds of agricultural production is consumed on-farm. Whereas this farm-based approach to food insurance is feasible for the small and rapidly diminishing group of households with sufficient access to land, it is infeasible for the increasing numbers of land-scarce farm households. In the absence of comprehensive, alternative food-insurance market mechanisms, including credit markets, the poor see no other option for coping with risk than maintaining the highest levels of subsistence food production along with income diversification in the off-farm labor market. The rapidly expanding cultivation of crops that yield high food energy per hectare with low levels of external inputs—especially the sweet potato, identified in this study—is a result of these forces that are driving farmers away from agricultural commercialization. Thus, the poor are too poor to capture the gains from efficient specialization because they need to take care of subsistence-based insurance against hunger.

Given this situation, technological change in the subsistence crops becomes central to household food security. However, as the long-term model scenarios in this study have shown, technical change in subsistence crops alone cannot be the long-term solution: diversification of the rural economy with specialization in agriculture and nonagriculture, fostered by an improved human capital and infrastructure base, must remain the strategic perspective. Achieving employment expansion jointly with increased labor productivity is the challenge.

Long-term analyses suggest an increase of the person-land ratio from 5.5 in 1985 to 12.0 adult-equivalent persons per hectare in the study area in 2005. Most dramatic is the labor supply expansion for nonagricultural employment that will, even under cautious assumptions in the simulations, more than double from its already high levels. Employment needs to be directed toward capital formation in agriculture. Upgrading the agricultural resource base by labor-intensive erosion-control measures such as terracing can be central activities in this context. Public investment for this upgrading is justified because of the conflict between the need of the poor to cope with short-run survival and the long-run sustainability of the resource base for society's food security. Public works activities may play an increasingly important role in this context. Any measures in this field of agricultural resource improvement have to take account of women as the predominant agricultural labor force and of women's time constraints.

Currently, the rural labor market in Rwanda is highly segmented. Women are primarily in agriculture, particularly subsistence crops, whereas men are employed mostly off-farm. The pressure for increased output per unit of land in subsistence cultivation due to increased population pressure will largely fall on women. In principle, technological change in subsistence crops could be expected to directly benefit women's employment, income, and income control. Yet, to the extent that such technological change requires external inputs, women's subsistence focus and related liquidity constraints will hinder technology adoption. For example, potato production with modern inputs is much more a "man's crop" than the traditional subsistence cultivation of the same crop. Tea, however, has opened up employment opportunities for women off-farm. Rapid expansion of women's employment and attention to constraints to adoption of new technologies in subsistence crops are central to women's and children's livelihood in this setting. In support of this conclusion is the finding that incremental women's income translates into incremental household food consumption (calories) over and above the income effect.

The study draws attention to the potential conflict between the concern for (export) diversification of the national economy and household food security. The social costs and benefits of export diversification are not equally distributed, and, in reality, absolute losers were created when tea production—found to be generally a success in Rwanda—was pushed into farm communities that relied heavily on subsistence food for food insurance. Farmers displaced by government tea plantations were found to have a major loss in their assets. Land tenure policy and issues of compensation for asset loss require careful case-specific consideration in the process of commercialization, especially in such land-scarce environments as this study area.

It is not surprising that at the very low levels of income noted at the study site, incremental income goes a long way toward reducing underconsumption and improving child nutritional status. However, malnutrition in this environment is to a very large extent also a health problem that needs to be addressed by the health and sanitation services. The study results highlight the large impacts on child growth that could be achieved by clean latrines, diarrhea control, and cures for intestinal worms. Creation of an effective demand for health services, however, requires household income growth, for which agricultural growth through commercialization and technical change again are instrumental. Thus, public action for health and sanitation in order to reduce malnutrition has to move in tandem with public action to stimulate rural growth through commercialization and technological change in agriculture. In the long run, the sustainability of public services, including health and sanitation services, depends upon the success of the rural growth. In the medium run, development assistance has to provide the bridge.

APPENDIX 1

SURVEY DESIGN

As described in the conceptual framework, addressing the research questions requires an integrated approach toward the household production-consumption-nutrition relationships. To empirically fill this conceptual framework, a complex farm household-level data collection was executed in the study area during 1985 and 1986. The survey instruments consisted of the following structured questionnaires to collect information on

A. Household demographics.
B. 1. Food consumption at the household level over one week (during three survey rounds).
   2. Food and nonfood expenditures and use of own-produced food in the household (between the three survey rounds and for extended seasonal recall periods).
C. 1. Health of women (mothers) and their children under age 7.
   2. Nutritional status measures (weight and height of women, men, and children).
D. 1. Agricultural production and crop-use information.
   2. Size of fields (measured or estimated) and certain field characteristics.
   3. Crop yields (in a subsample).
   4. Labor inputs by crop or system (in a subsample).
   5. Basic information on livestock.
   6. Off-farm work and income from all sources.

The precoded questionnaires written in Kinjarwanda for structured interviews were developed and pretested during the second half of 1985. Survey work by a team of enumerators trained during a three-month period in the field was ongoing from December 1985 to October 1986. A team of female enumerators covered questionnaires B and C mentioned above, and a male team covered most of the information in questionnaires A and D.

The actual survey work of the main sample was structured by three separate survey rounds: the first in January-March 1986, the second in May-June 1986, and a third in August-September 1986.

The first survey round included a long-term recall on agricultural production and off-farm income during 1985. The second and third rounds covered the 1985/86 main growing season and the short 1986 season, respectively.

Each survey round consisted of numerous interview sessions, with the respondents (head of household, wife) to the various questionnaire types adjusted to the specific household situation.

To meet the objectives of the research, the sample households were selected in a stratified way, and an attempt was made to arrive at a sample that would cover a significant range of the degrees of commercialization in an area reasonably homogeneous in agroecological terms. As no census-type information is available for the communities, an alternative way of selecting the sample households was chosen, following location-specific stratification.

For reasonable interhousehold comparison, the study area was limited to the high-altitude area.[22] The seven high-altitude *secteurs* of Giciye *commune* were divided into two groups based on their different population densities (population density being related to importance of pasture land, livestock, and other factors). At the same time, this stratification guaranteed that for both groups of *secteurs*, the distance to the Gishwati potato production area as a major source of commercialization was different. From each of these two groups of *secteurs*, two *secteurs* were chosen at random, a selection that resulted in the choice of Gasasa, Birembo, Rubare, and Murambi *secteurs*. Table 53 provides some information on all *secteurs* and the selected ones.

In each of the *secteurs*, two *cellules* were then selected, for a total of eight *cellules*. For this selection, meetings were organized with community leadership of the respective *secteur* and representatives of its *cellules*, in which the latter were asked to indicate, according to their subjective judgments, the importance of certain agricultural products (such as tea, potatoes, livestock) in each *cellule* of the *secteur*. An attempt was made on the basis of these judgments to choose in each *secteur* one *cellule* with a relatively high degree and one with a relatively low degree of commercialization. This selection resulted in the choice of Gasasa (commercialized) and Nyarusongati (less commercialized)

Table 53—Population density and land use for potatoes and tea in *secteurs* of Giciye *commune*, 1985

Secteur	Population Density	Average Land/ Household[a]	Share of Potatoes in Land Use	Share of Tea in Land Use
	(persons/square kilometer)	(hectares)	(percent)	
Birembo[b]	374	1.20	19.5	0.5
Cyarwa[c]	919	0.50	...	...
Gasasa[b]	595	0.77	7.7	0.7
Gihira[d]	500	0.92	7.4	n.a.
Jomba[c]	406	1.13	0.8	...
Kintarure[c]	432	1.07	...	...
Murambi[b]	443	1.04	1.4	1.4
Mutanda[d]	409	1.12	4.9	...
Nyamugeyo[d]	289	1.59	8.0	0.8
Rubare[b]	267	1.72	12.5	1.6
Rubona[c]	531	0.87	...	...
Shaki[c]	327	1.41	0.4	...
Shyira[c]	487	0.94	...	...

Source: Records of Giciye *commune*.

Note: n.a. means not available.

[a]This is not actual farm size but area divided by households, including noncultivated or noncultivable land.

[b]*Secteur* in study sample.

[c]*Secteur* not considered for sample random draw because of location in low-altitude zone.

[d]*Secteur* in high-altitude zone but not selected for study.

[22]In a neighboring low-altitude area, J. Laure (1982) has undertaken a carefully designed case study on the food crop-tea competition and related food-consumption effects.

cellules in Gasasa *secteur*, Ruhanga and Muremure in Rubare, Cyugi and Karambi in Birembo, and Gisoro and Ruhunga in Murambi.

Upon the identification of these eight *cellules*, their leaders were requested to provide lists of the names of the heads of households. There was a range of about 85-175 households per *cellule* among these eight *cellules*. From these lists, 22 households were chosen at random per *cellule*, resulting in 176 households.

To permit better assessment of the role of tea, the number of teaholders in the sample was increased. Households in smallholder tea production (*thé villageois*) were chosen at random from the lists of the Rubaya tea factory. This choice was limited to the *secteurs* already sampled. With that constraint, these 22 additional tea households came largely from Murambi *secteur* (both Ruhunga and Gisoro), bringing the total sample size to 198. After a few dropouts, the final count was 192 households. Two households were dropped from the analysis because of enumeration problems.

Finally, a specific group of households was included—those affected by the expropriation of property conducted by OCIR-Thé as part of the expansion of plantation tea at Nyabihu in Karago *commune*. Sampling of these households proceeded as follows. A list of the heads of 58 households affected by the expropriation and still residing in the area was provided by the representatives of the Nyabihu *cellule*.[23] Twenty-one of these households were chosen at random and interviewed with a simple expropriation and general identification questionnaire. Of these 21 households, 3 were chosen at random from households with no small children and 5 at random with small children. These 8 households responded to questions approximating one round of the main study in Giciye *commune*. Together with a group of displaced farmers who were captured by the main sample in the surroundings of the Rubaya tea factory, a total of 32 such displaced farm households are included in the survey.

To sum up, sample selection criteria were altitude zone (*commune* level), population density (*secteur* level), and degree of commercialization (*cellule* level). This sample was supplemented by small samples of households in smallholder tea and farm households expropriated because of factory tea expansion.

Additional data collection was done at market level (prices) and on various production activities (for example, beer brewing) at household level in subsamples.

[23]The number of displaced farmers totaled 450. The area of plantation tea established on land of displaced farmers was approximately 300 hectares, according to information provided by Nyabihu factory management.

APPENDIX 2

SUPPLEMENTARY TABLES

Table 54—Age-specific birth rates of Gisenyi *prefecture*, 1983

Age Group	Live Births per 1,000 Females
15-19	59
20-24	340
25-29	430
30-34	408
35-39	342
40-44	224
45-49	110

Source: Rwanda, National Population Office, *Enquête nationale sur la fécondité* (version résumée et version complète) (Kigali: NPO, 1985).

Table 55—Death rates by sex and age cohorts used for the demographic model

Age Cohort	Male	Female
0-4	0.22	0.22
5-9	0.06	0.06
10-14	0.001	0.0082
15-19	0.0372	0.0311
20-24	0.0391	0.0253
25-29	0.0186	0.0151
30-34	0.0136	0.0271
35-39	0.0018	0.0126
40-44	0.0058	0.0456
45-49	0.0250	0.0300
50-54	0.0090	0.0019
55-59	0.0132	0.0216
Above 59	0.0770	0.0136

Source: Authors' computations from the distribution of the total Rwandan population in 1978 and 1983 in Rwanda, National Population Office, *Enquête nationale sur la fécondité* (version résumée et version complète) (Kigali: NPO, 1985).

Table 56—Coefficients used to calculate the number of adult-equivalent persons

Age Group[a]	Coefficient
5-9	0.1
10-14	0.2
15-54	1.0
55-59	0.6
60-69	0.47[b]

[a]Male and female.

[b]This coefficient has been derived by multiplying the share of persons of this age group in the total population above 60 years of age by 0.6.

Table 57—Coefficients used to calculate the number of consumer-equivalents

Age Group	Male	Female
0-4	0.20	0.20
5-9	0.50	0.50
10-14	0.75	0.70
Above 14	1.00	0.75

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Joachim von Braun is the director of the Food Consumption and Nutrition Division at IFPRI, where he has been a research fellow since 1982. Hartwig de Haen is the assistant director-general of FAO, Agriculture Department. Juergen Blanken is a staff economist with the German Bank for Reconstruction (KFW)in Frankfurt.

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