

# 18 The Triple Role of Potatoes as a Source of Cash, Food, and Employment: Effects on Nutritional Improvement in Rwanda

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## Introduction

Potatoes, of all food crops, had the fastest average annual growth rate of production in Rwanda between 1970 and 1985: 6.8 percent. This increase in potato production was mainly brought about by a rapid expansion of the cultivated and harvested acreage, which grew by 6.7 percent per year during the same period, whereas average yields only slightly increased by 0.1 percent per year. In 1983, potato production covered an estimated 3.3 percent of the total harvested food crop acreage, and contributed to 3.1 percent of total calorie production (Delepierre 1985).

Given the extreme scarcity of arable land and the rapidly increasing demand for food due to a high rate of population growth, the intensification and diversification of domestic food production are the main objectives of the national agricultural development strategy (Ministère du Plan de Rwanda 1983). Potatoes, in particular, are slated to play a major role in this respect in the future. According to the Ministry of Agriculture's projections, potato production will expand by 5.2 percent per year between 1980 and 2000. Higher yields (4.1 percent per year), rather than area expansion, are assumed to be the major source of future growth.

Within Rwanda, both production and consumption of potatoes are concentrated in only a few growing areas. Following the Rwandan agro-ecological classification system, two major regions can be distinguished—the Volcanic Highlands and the Central Zaire-Nile Divide (Jones and Egli 1984).

In the Volcanic Highlands, prevailing environmental conditions are very favorable for potato cultivation: deep and fertile soils, abundant rainfall following a continuous distribution, and mild temperatures permit cultivation almost throughout the year. It is in this zone that potato production has expanded most rapidly in recent years and that potatoes have attained the highest share in total food crop acreage. Besides the

favorable environmental conditions, both input and output market infrastructure are relatively well developed and have led to a more intensive use of modern production technology such as improved seeds, fungicides, and spraying equipment.<sup>1</sup>

The percentage of marketable surplus is also highest in the Volcanic Highlands, and has been estimated at 45 percent of total potato production. This region also provides the bulk of the potatoes that are distributed and marketed in the non-potato-growing regions of Rwanda, particularly the urban centers.

Compared to the Volcanic Highlands, both environmental and market conditions are much less favorable in the Central Zaire-Nile Divide. In general, poorer soils and prevalence of very steep slopes render crop production more difficult, causing severe erosion problems. This zone can be regarded as quite remote, since infrastructure and the transport system, in particular, are only poorly developed. Consequently, availability of modern potato production technology is more limited, and interregional marketing of production surplus is more expensive due to high transportation costs.

Within the Central Zaire-Nile Divide, a special and recent case of land use is the expansion of potato production into the former natural forest of Gishwati. In the northern part of the Gishwati area, a reforestation and pasture improvement project financed by the World Bank has been under way since 1980. Originally, farmers and project employees were allowed to cultivate potatoes in the cleared and reforested parts of the project area in order to keep weeds down. But in the last few years, potato cultivation has expanded rapidly and in an uncontrolled manner, even into areas outside the project.

The access to additional farmland, although probably temporary, has had a tremendous impact on the rural economy of the area. For participating households, such access to land provides an extra source of off-farm income and raises their potential food supply for subsistence. For the region, it generates additional employment and stimulates growth of food supplies on local markets. On the other hand, the Gishwati case may also have some rather problematic implications, whatever the future prospects of the reforestation project. If the authorities stick to the official plan and enforce regrowth of trees, the impact on the regional economy will come to an end and will later appear only as a short-term

1. There can be no doubt that the rapid expansion of potato cultivation in this area was, to a large extent, encouraged by the foundation of the National Potato Program in 1979. The headquarters are located in Ruhengeri. This program was supported by the International Potato Center (CIP). The main activities include selection, multiplication, and distribution of improved potato varieties, including research and extension (Scott 1986; Haugerud 1985).

effect. If, as appears more likely, farmers continue to cultivate the area and grow annual crops on steep slopes and marginal land, environmental damage from soil degradation and changes of the microclimate cannot be ruled out.

Whatever the final outcome, some interesting questions are raised: (1) How does availability of new technology and additional land (for potatoes) affect production patterns and commercialization? (2) What are the employment effects? (3) How is the incremental income used? and (4) What are the effects on food consumption and nutrition?

### **Potatoes in the Agricultural Production Systems**

The study was conducted in Giciye commune in the Central Zaire-Nile Divide in northwestern Rwanda. A detailed survey of production, marketing, income, consumption, nutrition, and health was undertaken during 1985–86, covering 200 households.

The farming systems—that is, land use patterns and technology—prevailing in the study area are exclusively based on smallholder agriculture. Land is extremely scarce at this location and, in 1985–86, average farm size was only 0.75 hectare. With an average family size of approximately five persons, the resulting average person-land ratio of four adult person-equivalents per hectare is extremely high by international standards. Due to high rates of population growth and rapidly increasing food requirements, former wood and pasture lands have been transformed into permanent arable land. This land transformation process also includes the cultivation of very marginal areas on steep slopes, and a reduction in fallow periods. As a consequence, the scope for livestock production is limited and the agricultural production systems are predominantly based on crop production.

Table 18.1 reveals that land use is dominated by the main cereals—maize and sorghum, which together accounted for half the total farm acreage. They are cultivated in both pure stands and mixed crops. Sweet potatoes and peas each averaged approximately 15 percent of land use. Forty-three percent of sample households had land in the Gishwati area to grow potatoes. While average farm size of households with and without access to potato fields in the Gishwati was identical, the average size of the Gishwati plots was 0.27 hectare, thus increasing the average size of holdings by approximately 36 percent from 0.74 to 1.01 hectares for households with Gishwati land.

Observed differences in land use shares of different crops on the core farms between households with and without Gishwati land cannot be related to differences in access to Gishwati land, but to the effect of different agro-ecological conditions. Farm households with access to

**TABLE 18.1** Land use of households with and without additional Gishwati land, Rwanda, 1985–86

Basic Resources and Demographic Indicators	Households With Gishwati Land	Households Without Gishwati Land	Average of All Sample Households
Number of households	18	24	42
Average farm size (hectares)			
Excluding Gishwati land	0.74	0.75	0.75
Including Gishwati land	1.01	0.75	0.86
Number of adult person equivalents	2.80	2.70	2.70
Number of consumer-equivalents	3.60	3.30	3.50
Altitude (meters)	2,428	2,244	2,322
Land use (as percent of total core farm) <sup>a</sup>			
Maize (including mixed)	37.0	24.8	30.0
Sorghum (including mixed)	13.2	19.4	16.8
Beans	2.0	9.4	6.3
Peas	21.9	10.5	15.4
Sweet potatoes	9.4	20.0	15.5
Potatoes (non-Gishwati)	0.0	2.0	0.2

SOURCE: Based on a survey conducted by the International Food Policy Research Institute.

NOTE: Based on a subsample of 42 households where detailed data on cropping systems have been collected.

<sup>a</sup>Core farm refers to the farmland, excluding Gishwati land.

Gishwati land were located on higher altitudes and grew relatively more maize and peas, in particular, and less sorghum, sweet potatoes, and beans.<sup>2</sup>

Farmers with access to Gishwati land did not grow any potatoes in pure stands on their own fields, although they did so on the Gishwati fields. These farmers continued to grow a considerable amount of potatoes in mixture with maize. Thus, it can be concluded that the introduction of improved potato seeds and the increasing availability of other modern production technology for potatoes neither motivated a change in technology nor led to higher shares of potatoes in the average core farm outside the Gishwati land. On the contrary, in the sample households, modern potato cultivation was almost exclusively restricted to the

2. Multiple regression showed, for example, that the land use share of maize increases, *ceteris paribus*, by 6 percentage points per 100 meters of altitude. The analysis further revealed that, within the same altitude group, the person-land ratio is the most important determinant with respect to different crop shares in total farm size.

Gishwati area. This leads to the more fundamental question of whether the farms outside the Gishwati area are more resistant against innovations and changes in the external economic environment. As will be shown, there are some obvious adjustments of the labor economy of the farm households, but not of the subsistence-oriented production system per se.

### **Factors Explaining the Stability of Production Patterns on Core Farms**

An obvious explanation for why farmers are eager to grow potatoes on the new land but not to expand the potato area on their own farms could be that potatoes are the only crop permitted on the new land but are not competitive to other crops. Yet this is not so evident; at least in terms of returns to scarce land, potatoes are rather competitive.

Table 18.2 summarizes the average land and labor productivity for the most important crops and cropping systems. Cropping systems at the study location are extremely labor intensive compared to other African countries. Potatoes have the highest labor input, an average of 622 person-days per hectare. Potatoes, with 5,526 million calories per hectare and season, yield the highest gross land productivity of all crops. The gross margin per hectare is also highest for potatoes. However, due to extremely high labor requirements, the labor productivity of potatoes is relatively low and ranks only fifth after maize (both in pure stands and mixed crops), peas, and sweet potatoes. In terms of gross margin per person-day, potatoes tend to be more profitable than cereals but less profitable than beans, sweet potatoes, and, in particular, peas.<sup>3</sup>

Given that potatoes show by far the highest land productivity, why do farmers at this extremely land-scarce location not shift to potato production on a larger scale on their own fields? Different environmental conditions cannot be regarded as a factor inhibiting a more widespread expansion of potato production outside the Gishwati area, at least for the higher-altitude zones of the study area. A closer look at technical and financial characteristics of potatoes as well as explanations by farm families suggests some other reasons why farmers have so far not specialized in this apparently profitable commodity: high cash requirements,

3. It has to be added that the data shown in table 18.2 relate to land and labor productivities per crop and season. Since the length of the vegetative cycles of the crops under consideration varies substantially from eight to nine months in the case of maize, sorghum, and sweet potatoes to five months for leguminous crops and potatoes, the possibility of double cropping exists, at least theoretically, for the latter. Especially for potatoes, two crops per year on the same plot have often been observed. Thus, the comparative advantage of potato cultivation with respect to land productivity in both physical and monetary terms might be even greater than the data in table 18.2 suggest.

**TABLE 18.2** Average land and labor productivity of different cropping systems, Rwanda, 1985–86

Item	Maize (Pure Stands)	Maize (Mixed Stands) <sup>a</sup>	Sorghum (Mixed Stands)	Beans (Pure Stands)	Peas (Pure Stands)	Sweet Potatoes (Pure Stands)	Potatoes (Pure Stands)	Tea (Smallholder) <sup>b</sup>
Total labor input (person-days per hectare) <sup>c</sup>	261.6 (0.42)	260.5 (0.38)	346.9 (0.64)	315.1 (0.24)	101.5 (0.56)	398.0 (0.63)	621.8 (0.78)	470.0 (0.40)
Yield (kilogram per hectare) <sup>c</sup>	1,037 (0.45)	— —	— —	875 (0.50)	476 (0.55)	5,055 (0.42)	9,615 (0.87)	2,692 (0.49)
Yield (1,000 calories per hectare)	3,383	3,789	3,649	2,655	1,488	5,472	5,526	—
Gross revenues (US\$ per hectare) <sup>d</sup>	161	281	226	292	159	281	642	329
Variable costs (seeds; fungicides for potatoes only) (US\$ per hectare) <sup>d</sup>	7	127	75	17	17	0	222	98
Gross margin per hectare (US\$ per hectare) <sup>d</sup>	155	154	151	275	142	281	419	232
Labor productivity (kilocalories per person-day)	12.9	14.6	10.5	8.4	14.7	13.7	8.9	—
Gross margin per person-day (US\$) <sup>d</sup>	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: Based on a survey conducted by the International Food Policy Research Institute.

NOTE: Based on a subsample of 42 households only where detailed data on cropping systems have been collected.

<sup>a</sup>Most frequently maize, beans, and potatoes.

<sup>c</sup>Figures in parentheses are coefficients of variation.

<sup>b</sup>Average for 1985–86 (annual).

<sup>d</sup>US\$1 = FRw 89.9 (1986 exchange rate; average of January–August).

higher risk of crop failure, seasonal labor bottlenecks, tastes and preferences, and insufficient information.

As indicated in table 18.2, potatoes have the highest per hectare cash requirement for fertilizer, seeds, fungicides, and other inputs. Furthermore, farmers often have to overcome seasonal labor shortages by hiring nonfamily labor, which causes additional liquidity problems. Risk of crop failure, due to diseases in particular, is also high for potatoes. Traditional dietary preferences tend to constrain change, since many households would have to reduce production of other subsistence crops in order to expand potato production, which would imply either an increase in the consumption share of potatoes or a higher dependence on food purchases in exchange for potato sales. While both types of adjustment do occur, elasticities of response are rather low. Although production patterns on the farms have turned out to be quite inflexible, the labor economy has responded much more noticeably to the new situation.

### **Impacts on Employment and Division of Labor**

Adoption of potato production in the Gishwati led to some noteworthy changes in the division of labor to agricultural production at both the interhousehold and intrahousehold levels. While the contribution of nonfamily members to the total annual labor input to potato production (23.0 percent) did not differ greatly from that to all crops (26.3 percent), the composition of the nonfamily labor input was quite different. Employment of daily wage laborers was very important in potato production. Wage labor contributed, on average, 44.5 percent of total nonfamily labor input to potato production. In general, the main source of nonfamily labor was reciprocal exchange with relatives or neighbors or both, which provided about 78.2 percent of the total nonfamily labor input, while the share of paid daily wage labor was only 17.8 percent.

Land preparation, harvest, and postharvest activities are the main operations in potato production for which wage labor is hired. In absolute terms, wage labor was hired for approximately 64 person-days per hectare and season. Hence, potato production in the Gishwati area significantly contributed to rural employment creation in the agricultural sector. It will be shown later that this aspect of employment creation is of paramount importance, since the vast majority of farm households at the study location are too resource poor to earn a living from agriculture alone and, therefore, depend heavily on off-farm income.

At the intrahousehold level, potato production significantly affects the gender division of labor in agricultural production. Women's contribution to total family labor input by crop and activity was always much

higher than that of men, and it is only in potato cultivation that adult males provided a substantial part, 41.7 percent, of the total family labor input.<sup>4</sup> While certain operations, like weeding, were gender specific and almost exclusively women's domain for most crops, men participated to a larger extent in all cropping activities for potato production. In households with potato fields in the Gishwati, men provided an average of 33.7 percent of total family labor input, compared to only 22.0 percent in households without access to Gishwati land.

The access to additional land outside the farms had two further interesting effects: it mobilized extra labor inputs by male family members, and it motivated a substitution of labor by capital on fields of the farms. Labor input of adult males for nonagricultural on-farm activities and off-farm work did not vary substantially between households with and without access to Gishwati land. Hence, the higher male adult labor input in agricultural production in potato-growing households led to an absolute increase in total annual labor input for all activities, from 162 to 175 days per male adult (an increase of 8 percent). Only marginal differences can be observed with respect to absolute total labor input per female adult and distribution of female labor input into agricultural and nonagricultural activities between the two groups of households (table 18.3). Thus, it can be concluded that adoption of potato production increased the overall level of employment per male adult, without reducing the labor input for other activities and off-farm work, in particular.

Another important impact of the incremental potato production is reduction in labor input intensity on the farm. Labor input intensity averaged 211 person-days per hectare and year in those households with potato fields, significantly lower than the labor intensity of 283 person-days for other households. Surprisingly, shifting labor from the farm to potato production was not detrimental to overall calorie production and average land productivity on the farm, because of increases in the capital intensity of production technology. Apparently, income from Gishwati production was partially invested in better quality tools for field work.

### **Food Availability and Commercialization**

The majority of the sample households cannot meet their subsistence requirements from own production on the farms and consequently depend to a large extent on additional market purchases. Although average farm size without the Gishwati land was, as pointed out earlier,

4. Adult women above 15 years of age contributed 74.1 percent of total annual family labor input, whereas the share of adult men averaged 25.3 percent, and the remaining share of 0.6 percent was provided by children of both sexes below 15 years of age.

**TABLE 18.3** Labor allocation in households with and without additional Gishwati land, by gender, Rwanda, 1985–86

Labor Input per Year	Labor Allocation			
	Households Without Gishwati Land		Households with Gishwati Land	
	Days	Share of Total (percent)	Days	Share of Total (percent)
<b>Adult male</b>				
Agricultural production	46	28.4	62	35.4
On-farm, nonagricultural activities	40	24.7	40	22.9
Off-farm work	76	46.9	73	41.7
Total	162	100.0	175	100.0
<b>Adult female</b>				
Agricultural production	106	60.6	110	60.8
On-farm, nonagricultural activities	69	39.4	71	39.2
Total	175	100.0	181	100.0

SOURCE: Based on a survey conducted by the International Food Policy Research Institute.

NOTE: Based on a subsample of 42 households only where detailed data on cropping systems have been collected.

almost identical for households with and without access to the Gishwati land, calorie production per household and per consumer-equivalent on the farm was higher, by 15 percent, for households with additional land in the Gishwati.<sup>5</sup> On average, potato production in the Gishwati provided an additional 40 percent calorie production, which raised daily calorie supply per adult consumer-equivalent of these households to 3,587 versus 2,184 calories in the non-Gishwati farm households. Assuming average annual requirements of approximately 2,800 calories per consumer-equivalent per day, potato production in the Gishwati thus enabled these households to become surplus-calorie producers.

Table 18.4 shows that production systems in the study area were very much subsistence oriented. In 1986, the average subsistence degree in agricultural production, defined as the value of subsistence production over the value of total agricultural production (including sales of animal products and home-produced sorghum beer), amounted to 73.7 percent.

5. The reason for the higher calorie production on farms with Gishwati income is partially due to higher altitude and related differences in cropping patterns. It is also the result of capital-labor substitution, as indicated before.

**TABLE 18.4** Overall degree of subsistence orientation in agricultural production and share of marketed surplus by crop, Rwanda, 1985–86

Crop	Households Without Gishwati Land (n = 105)	Households with Gishwati Land (n = 81) (percent)	Average of All Sample Households (n = 186)
Share of marketed surplus			
Maize	3.2	1.4	2.5
Sorghum	6.5	1.8	4.5
Beans	0.8	0.0	0.4
Peas	0.6	2.4	1.4
Sweet potatoes	6.3	2.6	4.7
Potatoes			
Non-Gishwati	0.5	0.8	0.6
Gishwati	—	28.7	—
Subsistence degree <sup>a</sup> (1986)	76.8	69.3	73.7

SOURCE: Based on a survey conducted by the International Food Policy Research Institute.  
<sup>a</sup>Defined as the value of subsistence production over the value of total agricultural production.

The subsistence degree was somewhat lower in households with access to Gishwati production.

The degree of market integration of all crops grown on the farms is rather small. Differences of minor importance can be observed for the marketed shares of sorghum and sweet potatoes, on the one hand, and for peas, on the other hand, but these might be attributable to differences in land use. Potatoes on the farm appear to be grown predominantly for subsistence consumption, as indicated by the low commercialization degree of 0.8 percent only. With a commercialization degree of 28.7 percent, Gishwati potatoes are the only crop marketed to a larger extent.

Access to additional land resources also affected interfarm equity within the group of households with access to Gishwati land. The size of the additional potato plots varied considerably from 0.02 hectare to 2.8 hectares. Grouping these households by the size of the core farm shows that households in the lower quartile were able to increase total farm size from 0.18 to 0.25 hectare, or by 38.8 percent, whereas, in the upper quartile, average farm size increased from 1.3 to 1.73 hectares, or by 33.1 percent. The inequalities with respect to access to potato fields in turn had an important impact on the use of the additional calorie production from potatoes (table 18.5). When households with access to Gishwati land are grouped by the level of calorie production per consumer-equiva-

**TABLE 18.5** Increase in farm size and calorie production in households with additional Gishwati land, by quartile of calorie production per consumer-equivalent, Rwanda, 1985-86

Item	Calorie Production per Consumer-Equivalent Quartile			
	First	Second	Third	Fourth
Farm size (hectares)				
Without Gishwati land	0.50	0.59	0.60	0.86
With Gishwati land	0.61	0.71	0.75	1.32
Increase (hectares)	0.11	0.12	0.15	0.46
Increase (percent)	22.0	20.3	25.0	53.5
Daily calorie production per consumer-equivalent				
Without Gishwati land	942	1,510	2,367	5,079
With Gishwati land	1,189	2,016	3,025	7,707
Increase (percent)	26.2	33.5	27.9	51.7
Total potato production sold (percent)	7.6	31.5	29.2	45.4

SOURCE: Based on a survey conducted by the International Food Policy Research Institute.

lent on the core farms, only minor differences existed among the first three quartiles concerning additional land in the Gishwati: the increase in total farm size ranged between 20 and 25 percent, whereas, in the upper quartile, total farm size increased drastically from an already high level of 0.86 hectare to 1.32 hectares (by 53.5 percent).

Although the additional calories from potato production substantially increased total calorie production of the first three quartiles, it did not allow these households to become surplus producers. The additional calories from potato production were primarily used for subsistence consumption, as indicated by the percentage of total potato production that was marketed. The marketed surplus in the first quartile, in particular, was extremely low and averaged only 7.6 percent of total Gishwati production. In the upper quartile, a considerable marketable surplus exists, and the average for the whole sample was 28.7 percent (table 18.4). Thus, it can be concluded that among the group of Gishwati farmers, it was the relatively richer households that participated in potato production to the greatest extent and thereby were able to expand their production and income potentials even further.

Another important aspect of potato production in the Gishwati is its impact on income control within the household. It is frequently found that in many Sub-Saharan countries women are mostly responsible not

only for cultivating food crops but also for their marketing. Women in this setting in Rwanda provide the bulk of the labor input in agriculture, but men participate to a larger extent in the new potato production. It was found that the higher male labor input in potato production also led to more male control over the use of that production. While women were responsible for most of the marketing of food crops in 75 percent of the households, they exerted dominant control over potato sales in only 25 percent of the households.

Finally, with respect to long-term implications, a warning must be expressed. Although the Rwanda case can be used to examine the short-term impact of extra agricultural off-farm income, it cannot be generalized as a case study of a stable long-run external source of extra employment and income. While the expansion of cultivated land provided a rather steady flow of additional income in earlier periods of low population pressure and extended forest areas, today the situation is drastically different, as Rwanda's agriculture has nearly reached a cropping frequency that approaches permanent cultivation year round. This has already caused yields of major crops to decline and forest areas to shrink rapidly. Given the engagement of farmers in potato production on newly cleared forest land, it is not unlikely that they will tend to keep the land cultivated and prevent the regrowth of trees, against the original intention of the project. This would certainly not only cause yields of potatoes to decline but would also establish severe ecological risks, a change toward a less humid microclimate, in particular.

While the production story of area expansion and new technology in potato production is certainly central to consumption potentials at household levels, behavioral factors come into play that permit us to assume only to a limited extent a direct translation of the production effects into food energy consumption effects, even in the very subsistence-oriented farm households. In the following two sections, we therefore make an attempt to explain calorie consumption and preschooler nutrition at the household level and, in this context, evaluate the role of commercialization versus subsistence orientation of production.

### **Calorie Consumption: Deviating Effects of Commercialization**

The calorie consumption model shows a strong relationship between income and calorie consumption: a 10 percent increase in income raises calorie consumption at the sample mean by 4.7 percent (table 18.6). Substantial differences exist between the top and bottom income quartiles' 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 house-

**TABLE 18.6** Estimation results for relationship between calorie consumption and subsistence orientation

Explanatory Variable <sup>a</sup>	Parameter	t-Value	Mean of Variable	Standard Deviation
TOEXCA	1,286.151	23.01	6.70	0.55
POTPRICE	-23.605	-2.54	8.56	3.55
POTSWEET	-114.406	-1.21	0.84	0.37
SUBFOOD	13.667	10.41	49.23	21.50
CAPITA	-373.914	-5.63	1.61	0.46
CHSHARE	1,400.815	9.64	0.29	0.20
FEMHEAD	376.931	4.13	0.11	0.32
ROUND1	384.618	5.25	0.33	0.47
ROUND2	390.543	5.24	0.33	0.47
Constant	-6,480.784	-14.681	—	—
(CALADEQ)	—	—	2,611.84	1,102.30
$\bar{R}^2$		.657		
F-value		120.3		
Degrees of freedom		551		

NOTE: The dependent variable is CALADEQ = Calories per day per adult-equivalent person.

<sup>a</sup>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	= ratio of potato price over sweet potato price
SUBFOOD	= consumed own-produced food (value in percent of total expenditures)
CAPITA	= household size (number of persons)
CHSHARE	= percent of children under five per capita in households
FEMHEAD	= female-headed households = 1, else = 0
ROUND1, ROUND2	= dummy variable for survey rounds 1 and 2 = 1, else = 0

holds and by 5.5 percent in the top quartile households (these estimation results are not listed in table 18.6). The propensity to consume more food with rising income is high, even among the “rich” in the top quartile (total expenditure per capita is US\$224 per year in this “rich” group).

Increased subsistence orientation (lower commercialization) raises calorie consumption over and above the price and income effects. This increase is statistically significant. The influence of that effect is also quite substantial: a reduction in subsistence orientation by 10 percentage points from, say, 50 percent to 40 percent of value share of consumption from own production in total expenditures leads to a 5.2 percent drop in calorie consumption, holding other variables constant.

The model analysis confirms that female-headed households—*ceteris paribus*—consume higher levels of staple food on per capita terms than do other households. In bottom quartile households, female-

headedness of households implies a 17 percent higher per capita calorie consumption level than found in other households. This effect is confined to female-headed households among the poor. In the top quartile expenditure class, the effect of female-headedness of households on calorie consumption is not significant. This result could be interpreted that in the poorest households where women are in control of resource allocation, relatively more is spent and allocated in terms of household production resources toward nutritional improvement, but this effect is no longer apparent when basic food requirements are satisfied as in the top expenditure quartile.

### **Nutrition Effects of Commercialization: Health and Sanitation Effects Dominate**

Nutritional effects of commercialization are not only driven by income-consumption linkages but also by the health and sanitation environment of the household. The nutritional status of children aged between six months and seven years is evaluated by using anthropometric measurements of weight and height. WHO-NCHS standards were used as reference population statistics to identify prevalence of malnutrition and nutritional status of individual children. It must be remembered that child growth is not an indicator that enables us to distinguish food deprivation from infection as an initiating event (Payne 1987).

The child population in the survey households was weighed and measured before the initial survey and during each survey round. In the beginning of 1986, 21.5 percent of children were growth retarded, that is, they were below 90 percent of the reference height-for-age. About 10 percent of the children were underweight, that is, they were below 80 percent of the threshold level of weight-for-age, and 5 percent were showing symptoms of wasting, that is, their weight-for-height was below 90 percent of reference standards.

A straightforward comparison of nutritional status in households that are and are not involved in cultivating new potato fields in the Gishwati shows a lower prevalence of malnutrition in households with commercial potato fields.<sup>6</sup> This may largely reflect a positive relationship between income and nutritional improvement. Multivariate analysis to explain differences and short-term changes in children's nutritional status sheds further light on this.

The results are presented in table 18.7. There is a statistically significant nutritional improvement effect of the incremental food consump-

6. Height-for-age Z-scores: - 1.22 with Gishwati, - 1.68 without Gishwati. Weight-for-age Z-scores: - 0.46 with Gishwati, - 0.71 without Gishwati. Weight-for-height Z-scores: 0.31 with Gishwati, 0.28 without Gishwati.

TABLE 18.7 Multivariate analysis of determinants of nutritional status of children, 6–72 months

Explanatory Variable <sup>a</sup>	MODEL 1				MODEL 2				MODEL 3			
	Height-for-Age (HAZ)				Weight-for-Age (WAZ)				Weight-for-Height (WHZ)			
	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	— <sup>b</sup>	—	—	—	— <sup>b</sup>	—	—	—	-4.88E-08	-2.41	7732319	6112009
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	2.30	0.51	0.50
CLEAN TOILET	0.5295	5.55	0.60	0.49	0.2151	2.94	0.60	0.49	— <sup>b</sup>	—	—	—
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	-14.61	-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				.05643			
F-value	10.78547				7.46429				4.79772			
Degrees of freedom	613				613				625			

<sup>a</sup>Definitions of variables:

CALORIES = calories per adult-equivalent per day

CALORIES SQUARED = (calories per adult-equivalent per day)<sup>2</sup>

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, etc.

SEX = sex of child, 1 = male, 2 = female

AGE = age in months at time of taking anthropometric measures

HEIGHT OF MOTHER = height of mother in centimeters

HEIGHT OF FATHER = height of father in centimeters

<sup>b</sup>Not in equation.

tion and, in the case of the short-term nutrition indicator (weight-for-height), the effect is also decreasing at the margin.<sup>7</sup> Although the calorie consumption effect is highly statistically significant, the net effect in improving nutritional status is small. For example, a 10 percent increase in calories in a household that consumes 2,000 calories per adult-equivalent person would increase the Z-score weight-for-height value of children in this household, *ceteris paribus*, by 0.021 (8 percent of the mean value of the sample's weight-for-height), the Z-score height-for-age value by 0.035 (2.3 percent), and the Z-score weight-for-age value by 0.019 (2.9 percent). Nevertheless, other than in the case from Kenya (chapter 16), a clear relationship between the (largely potato-driven) income-expenditure–food consumption linkages to the nutritional status of children is established with this study.

Similarly, as in the case from Kenya (chapter 16) and several other cases (chapters 12, 14, 22), health and sanitation-related variables overshadow the consumption impact on nutrition. As expected, current underweightness (weight-for-height and weight-for-age below standard) is substantially a result of current or recent morbidity or episodes of morbidity. This is not the case for the height-for-age model, in which there is a strong adverse effect of worm infestation on the long-term growth performance of children. Children severely affected by worm infestation (which is actually the case for half of the child population in the survey) have a Z-score for height-for-age that is 17 percent lower than the mean.

Improved household sanitation significantly improves children's nutritional status. The CLEAN TOILET variable might be interpreted as a proxy for more generally improved household sanitation conditions. The CLEAN TOILET parameter estimate suggests that improved sanitation conditions, in comparison to poor conditions found in 40 percent of the households, lead to an approximately 33 percent improvement in both height-for-age and weight-for-age indicators.

The results from this multivariate analysis underscore that malnutrition in this environment is to a very large extent a health problem that requires tackling the health and sanitation side of rural services in tandem with the employment and income problems. Clearly, for this population as well as for other similarly poor ones (see chapter 20 for Malawi), income matters for nutritional improvement, as the earlier aggregate analysis showed (table 3.3).

7. The latter result was not found in models 1 and 2 for the height-for-age and weight-for-age model, respectively, where the squared calories variable was, therefore, dropped from the model.

## Conclusions

The major findings of this study are summarized:<sup>8</sup>

1. Due to extreme land scarcity and market risks, farmers tend to be rather reluctant to adjust their production systems to a changing economic environment. Subsistence production has a high priority in this setting, which will be the case as long as infrastructure deficiencies imply high price risks, and off-farm employment (which already provides 55 percent of average household income) is risky and unstable.
2. While crop production patterns are quite stable, technologies are adjusted more elastically, as exemplified by the case of potatoes. Off-farm incomes are partially used to invest in farm equipment and improved tools. As a result, yields improve and some family labor is released for other activities.
3. New potato production had a double impact on employment of family labor: mobilization of extra male labor capacity, which was thus far underemployed, and capital-labor substitution. Also, the rural wage labor market expanded.
4. Land scarcity and low productivity in the study region make off-farm incomes indispensable for meeting farm families' minimum food requirements. New employment in specialized potato production had the extra property of combining increased purchasing power with additional supply of staple food.
5. Access to additional land resources did not reduce existing inter-household differences in income and food supply; in fact, inequities were further widened.
6. In evaluating the overall role of expanded potato production, direct benefits have to be balanced against external costs over the short and long run. Benefits result from the triple role of potatoes—extra employment, income growth, and increased food supply. However, these benefits might sooner or later decline as a result of environmental degradation. Compared to the original forest, soils under potatoes are subject to erosion and nutrient run-off. Moreover, the loss of forest area may have negative implications for the regional climate and biodiversity.
7. Calorie consumption is found to increase rapidly with rising income in this very poor area. However, increased commercialization (reduced subsistence orientation in production) results in lower calorie consumption per adult-equivalent person, holding income constant.

8. These conclusions also include some generalizations documented in greater detail in von Braun, de Haen, and Blanken (1991).

This latter effect seems to relate to male control over incremental cash income from the potato production and lump-sum cash income from the crop. However, the positive income effect of potato production was larger than the deviating effects of the control and form of income for calorie consumption at the margin. Thus, food consumption could increase.

8. Nutritional improvement of children at the study location is largely determined by health and sanitation conditions. Yet, incremental calorie consumption in food-deficient households is also found to improve child nutritional status. To the extent that incremental potato production increased household calorie consumption and household ability to invest in human welfare and health directly and indirectly, it added to nutritional improvement. Growth in employment and income of the poor needs to move in tandem with provision of rural public health and sanitation services in order to maximize the benefits of both—private income growth and public services expansion—for nutritional improvement.