Household Income, Food Availability, and Commercial Crop Production by Smallholder Farmers in the Western Highlands of Guatemala*

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Maarten D. C. Immink
International Food Policy Research Institute

Jorge A. Alarcon
Mississippi State University

Introduction

Crop commercialization among smallholder farmers in developing countries has often been signaled as being detrimental to the economic conditions and food security of the farmers' households.[1] High variability in market prices of farm products and farm inputs poses significant risks to household income, as do inefficient marketing institutions and inadequate rural infrastructure. Lack of adequate access to credit prohibits smallholder farmers from assuming such risks. Commercialized farm households become more dependent on market conditions for adequate availability of food, as cash crops displace food crops and household consumption of own-produced staple foods is reduced. Thus, the household's vulnerability to food insecurity tends to be increased. Labor inputs by household members are often higher in cash than food crops, which may increase the household's food needs.[2] Changes in food intake patterns have been associated with a change toward cash crop production, which often results in diminished nutritional quality of the diet.[3]

The income and food effects of shifts from subsistence to commercial crop production are likely to be time and place specific, as a review of evaluations of cash-cropping schemes has indicated.[4] A series of recent case studies undertaken in Africa (Kenya, The Gambia, Rwanda), the Philippines, and Guatemala has provided additional results.[5] The broad findings of these studies indicate that shifts toward

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commercial crop production involve significant reallocation and increased productivity of household resources (particularly land and labor) and are associated with significantly higher household incomes. Of relevance here is the point stressed by M. Lipton and R. Longhurst that when farm-level specialization leads to the adoption of new technologies, yield increases are likely to result.[6]

Total household food availability may not be negatively affected and may actually be somewhat higher, although the short-term income-caloric intake relationship is generally weak. Economic costs and benefits are also conferred on community members who do not participate in the cash-cropping schemes, as both land values and employment opportunities on participating farms increase. The results stress the point that the specific economic and food security outcomes are likely to be conditioned by the macro-level policy environment consisting of marketing conditions, market prices, rural infrastructure, access to credit, and technological change focused on food crop production.[7]

In this study we examine the economic and food availability outcomes associated with different crop patterns among smallholder farm households in the western highlands of Guatemala. Specifically, we identify factors that are associated with crop mix decisions by smallholder farmers, and we examine the associated effects on the allocation of household resources. Next, we look at the differences in income levels and in income disparity associated with different crop mixes, and how the food availability of the household as a whole, as well as of the preschool child (as the most vulnerable member) may be affected. This case study differs from crop commercialization studies which examine the effects associated with a complete substitution of cash crops for food crops. Instead, we compare farmers with different crop mixes: all, however, include maize and/or beans, that is, basic food crops.

Methods

The study covers a population of smallholder farm households in the western highlands of Guatemala. The altitude there ranges from 900 to 3,400 meters above sea level, and only a fourth of the land is under cultivation. Smallholder farming systems, low agricultural productivity, and poor access to major markets characterize this region. The population is predominantly indigenous. Major staple crops are maize and beans and a major cash crop is wheat. It is an area that has been suffering for many years from political violence and military repression and at present continues to do so. This has led to displacement of a significant percentage of the population, has interrupted productive activities, and has contributed to an increasing impoverishment of the population.

In 1982 the government of Guatemala initiated in this region a crop diversification program for smallholder farmers, primarily based on cold-weather vegetables for domestic and foreign markets. The program, financed with foreign loan funds, aims at improving the socioeconomic well-being of subsistence farmers and their households by means of increased household income and on-farm employment, and increased household availability of a more diversified diet. Cold-weather vegetable production and consumption by smallholder households are promoted by means of credit programs for mini-irrigation systems, soil conservation and farm inputs, agricultural extension services, and food and nutrition education programs.

A comparison between program participants and nonparticipants revealed a selection bias of program participants: higher literacy rates and average educational attainment, and larger farm size.[8] Participant farmers appear to have been selected to maximize the likelihood of the program's success in terms of adoption and diffusion of new production methods. The program was originally targeted at 4,000 farmers; it is not known how many farmers participated in (or had graduated from) the program at the time of the study.

The study brings together data from two different sources. A farm production and household expenditure survey was conducted by the Ministry of Agriculture, Livestock and Food (MAGA) among 1,490 smallholder farmers in February–March 1987. The sample selection procedure was a two-stage random selection method using selection criteria in the first stage for communities and then for diversification program (non)beneficiaries. Households were selected at random in each community and thus included traditional and diversified farm households. The Institute of Nutrition of Central America and Panama (INCAP) conducted a food intake survey 8 months later among 906 households of the MAGA sample, selected by means of a single-stage conglomerate method in which communities constituted the conglomerates. The food intake of the household as a whole, and of one preschool child (6–60 months of age) if present, were measured by means of the 24-hour recall method. The food intake data were converted into daily energy and protein intakes using the Central American food composition table.[9] Intake of breast milk was not measured; thus the total food intake of the youngest children was probably underestimated. For this reason, children between the ages of 6 and 12 months were subsequently eliminated from the analysis. Age- and gender-specific recommended daily allowances of dietary energy and protein were used to calculate adequacy levels for the household as a whole and for the preschool child.[10] The INCAP also obtained data regarding the household's participation in credit and agricultural extension programs during the previous year.

The households in the INCAP subsample were ex post classified into four groups based on different crop mixes: (*a*) "traditional" or maize farmers (maize and/or beans production), (*b*) "potato farmers" (maize and/or beans and potatoes), (*c*) "wheat farmers" (maize and/or beans and/or potatoes and wheat), and (*d*) "vegetable growers" (maize and/or beans and/or potatoes and vegetables). The total number of households so classified was 786, which means that 120 households (13%) were excluded from the analysis. These households exhibited such diversity in crop mixes that any further meaningful classification was not possible.

A number of limitations are imposed by the study design. The cross-sectional study design does not allow us to deal with the question of intertemporal stability in crop-mix patterns. Some variables reflect accumulative processes that are not necessarily attributable to a given crop-mix pattern. The farmer group classification does not take into account relative crop shares in total farm production. To our knowledge, however, diversified farmers in the study region are more likely to adjust relative crop shares from one crop cycle to the next (most frequently observed between maize and wheat) than to revert back to only maize production. With our approach misclassification errors over time are reduced, but conclusions about outcomes associated with crop-mix patterns are less robust. The ex post classification of the farmers means that the groups were not necessarily representative of all farmers in the region with the same crop-mix patterns and that the subsample of the vegetable growers was not necessarily representative of all participants in the government's crop diversification program. This limits the generalization of the findings which cannot be fully overcome by the multivariate approach used in the analysis.

Relating data obtained during two separate periods, particularly when key variables are subject to seasonal variation, may introduce estimation errors. For example, household income in February–March may be below average while food intake levels in October–November are generally above average right after harvest time (though seasonal variation of daily energy intakes have been found to be far less pronounced than expected in this region). Key variables were categorized in the analysis in order to compensate for any seasonal variation; this in turn provides less robust conclusions, of course. Last, the cross-sectional study design does not allow us to reach conclusions about causal effects but only about outcomes associated with different crop patterns.

Farmer and Household Characteristics

Forty percent of the (reduced) subsample fell in the first farmer category ($N = 313$), 24.2% in the second ($N = 190$), 15.3% in the third ($N = 120$), and 20.7% in the fourth ($N = 163$). Maize was grown by 97% of the total subsample, beans by 33.4%, and potatoes by 37.9%. The principal vegetables grown by the fourth group were cabbage

TABLE 1

SOCIOECONOMIC AND DEMOGRAPHIC CHARACTERISTICS OF SMALLHOLDER FARM HOUSEHOLDS, BY CROP PATTERN, WESTERN HIGHLANDS, 1987 (% Distribution)

CHARACTERISTIC	FARMER GROUP (N) MF (313)	PF (190)	WF (120)	VG (163)
Farm size (ha):				
<.5	50.2	18.4	10.8	17.3
.5–1.0	20.3	34.7	25.8	24.1
1.0–2.0	17.7	27.9	28.3	26.5
>2.0	11.9	18.9	35.0	32.1
Cropland extension (ha):				
≤.5	65.5	31.6	23.3	37.0
>.5	34.5	68.4	76.7	63.0
Head of household:				
Literate	50.2	55.6	63.6	54.2
Some formal education	45.9	48.4	59.8	51.3
Spouse:				
Literate	22.9	16.4	35.6	32.5
Some formal education	21.5	16.0	31.9	30.7
Household size:				
1–3 members	14.8	12.7	10.1	9.0
4–6 members	49.8	49.2	46.2	39.1
>6 members	35.4	38.1	43.7	51.9
Credit/extension services received previous year:				
None	71.9	23.7	46.7	29.4
Credit only	6.4	20.0	20.8	15.3
Extension services only	5.1	11.1	3.3	6.1
Credit and extension services	16.6	45.3	29.2	49.1

NOTE.—MF, maize farmers; PF, potato farmers; WF, wheat farmers; VG, vegetable growers.

(27.0%), carrots (18.4%), cauliflower (14.1%), red beets (12.9%), and broccoli (9.2%).

Diversified farmers tended to have larger farm size than maize farmers (table 1), while maize farmers exhibited considerably more disparity in landholding distribution than did diversified farmers (Gini coefficient, .74 vs. .49–.55). Heads of wheat-producing households were more often literate and had completed more formal education than other farmers. Literacy and achieved formal education by spouses was particularly low among the potato farmers' households. Vegetable-producing households tended to be larger in size and potato- and vegetable-producing households had more often received formal credit and or agricultural extension services than maize and wheat farmers. Informal sources of credit were not considered here. Formal credit and agricultural extension services most often went hand in hand and there was a clear tendency for farmers with larger holdings to be granted credit.

Crop Diversification and Household Resource Allocation

As may be expected, the amount of cropland allocated to maize production was lower with crop diversification, when comparing the weighted medians of the percentage of cropland allocated to different crops (maize farmers, 72%; diversified farmers, 40%–44%).[11]

The percentage allocated to maize remained fairly constant with cropland size among maize, potato, and wheat farmers but tended to be lower among vegetable producers with larger extensions. Beans were often intercropped with maize, but less intercropping appeared to take place on larger extensions. The percentage of cropland allocated to potatoes remained constant with extension size among the potato farmers but was lower among wheat farmers and vegetable growers, while the percentage allocated to wheat production remained generally constant with extension size as well.

Vegetables occupied generally a low percentage of total cropland (3%–12%): with the exception of broccoli, the percentage allocated to vegetables tended to be lower on larger crop extensions. These low percentages indicate that crop diversification based on vegetables was limited in terms of land allocation among the vegetable producers included in this sample.

Maize yields tended to be higher among wheat farmer's compared with potato and maize farmers and with vegetable growers, particularly on farms with more than half a hectare in cropland (table 2). Maize yields of maize farmers tended to be lower on larger crop extensions. Vegetable growers on small farms had slightly lower maize yields than

TABLE 2

Yields (100 kg/ha) of Selected Crops among Smallholder Farmers, by Cropland Extension Class, Western Highlands, 1987 (Weighted Medians)

	All				≤.5 ha				>.5 ha			
Crops	MF	PF	WF	VG	MF	PF	WF	VG	MF	PF	WF	VG
Maize	18	18	22	18	19	19	20	18	15	18	22	19
Beans	2	1	1	2	1	1	1	2	2	1	1	2
Potatoes	...	126	120	136	...	90	110	110	...	139	122	150
Wheat	...	...	17	...	...	...	13	...	...	...	18	...
Broccoli	...	...	...	89	...	...	...	51	...	...	...	95
Cauliflower	...	...	...	113	...	...	...	119	...	...	...	109
Cabbage	...	...	...	99	...	...	...	96	...	...	...	100
Red beets	...	...	...	125	...	...	...	160	...	...	...	111
Carrots	...	...	...	504	...	...	...	536	...	...	...	483

Note.—MF, maize farmers; PF, potato farmers; WF, wheat farmers; VG, vegetable growers.

maize farmers, but higher bean yields. Potato yields tended to increase in general with crop extension and were the highest among vegetable growers with larger farms. Wheat farmers who grew potatoes tended to have lower yields, while vegetable growers tended to have higher yields than potato farmers. Wheat yields increased somewhat with crop extension, as did broccoli yields, while yields of red beets and carrots showed the opposite trend. The yield changes and different land utilization patterns associated with crop diversification have important implications for household income and food security of smallholder farm households.

Vegetables and potatoes were more, and wheat was less, labor intensive than maize, as indicated by the labor-land ratios presented in table 3. Thus, substitution of potatoes and/or vegetables for maize in the crop mix created on-farm employment, especially as the labor-land ratio in maize production was generally not lower among diversified farmers. On-farm employment of hired labor in maize production was higher among wheat farmers and vegetable growers, while household on-farm employment levels among potato growers were the same as among maize farmers. Given the high labor-land ratios in vegetable production relative to maize, and the high percentage of household labor input, the household on-farm employment difference was strongest among vegetable growers and weakest among wheat farmers (only if they grew potatoes; if not, household on-farm employment was actually lower).

The differences in household on-farm employment were relatively larger among farmers with small cropland areas. For all crops, with the exception of beans, there was a positive difference in on-farm employment for hired labor. The same difference was also present on farms with larger cropland areas, after accounting for differences in labor-land ratios. This effect was particularly strong in carrot, potato, and red beet production, and considerably less in maize, wheat, cauliflower, cabbage, and broccoli production. With the exception of beans, cauliflower, and red beet production among maize and vegetable farmers, the supply of household labor per hectare was generally lower on larger crop extensions.

Off-farm employment tended to be most frequent among potato farmers and least frequent among vegetable growers (table 4). The male head of household was most often the household member employed in off-farm work. This tended to decrease in frequency with increased cropland area, except among vegetable growers. The reason for this difference in pattern is not immediately obvious. It is consistent with increased on-farm employment by hired labor on larger vegetable farms. However, it does not appear to be due to higher relative marginal returns in off-farm work by vegetable growers; only among wheat-growing households did we find evidence of a positive associa-

TABLE 3

Total Person-Days/Hectare/Year and Percentage Household Labor of Smallholder Farm Households, by Cropland Extension Class, Western Highlands, 1987 (Weighted Medians)

	All								≤.5 ha								>.5 ha							
Crops	MF		PF		WF		VG		MF		PF		WF		VG		MF		PF		WF		VG	
Maize	282	97	305	91	291	72	282	71	316	99	354	100	355	94	347	90	218	94	283	86	270	68	247	60
Beans	40	99	28	100	23	78	31	100	27	100	34	100	33	81	15	100	49	99	27	100	19	77	36	100
Potatoes	...	...	494	87	585	79	629	78	...	...	552	100	762	92	562	93	...	...	467	81	547	77	668	69
Wheat	...	...	...	...	219	74	...	...	...	...	...	...	273	93	...	...	...	...	...	...	202	68	...	...
Broccoli	...	...	...	...	...	...	834	66	...	...	...	...	...	...	2.314	91	...	...	...	...	...	...	606	62
Cauliflower	...	...	...	...	...	...	1.070	90	...	...	...	...	...	...	939	91	...	...	...	...	...	...	1.179	90
Cabbage	...	...	...	...	...	...	959	95	...	...	...	...	...	...	1.037	98	...	...	...	...	...	...	913	93
Red beets	...	...	...	...	...	...	1.133	95	...	...	...	...	...	...	961	100	...	...	...	...	...	...	1,206	92
Carrots	...	...	...	...	...	...	1.159	80	...	...	...	...	...	...	1,032	88	...	...	...	...	...	...	1,233	74

Note.—The left-hand column under each farm type is person-days per hectare; the right-hand column for each is percentage of household labor of total labor. MF, maize farmers; PF, potato farmers; WF, wheat farmers; VG, vegetable growers.

tion between the farmers' human capital investment levels (higher literacy rate, more formal education completed) and cropland area. Off-farm employment by children tended to be higher on larger crop extensions in all four groups, which may reflect the positive association within each group between household size and crop extension.

Constraints to Crop Diversification
In order to understand farmer and other characteristics that appear to be associated with different crop-mix patterns in the western highlands, we specified and estimated the following probit model.

$$CP_i = f(\text{CROPLAND, HHLABOR, HHHCAP, LOCATION, CREDIT, SERVICES}), \quad (1)$$

where

CP_i = crop mix pattern;

i = 1, 2, 3;

CROPLAND = cropland extension under cultivation;

HHLABOR = *a*) number of household members over 10 years old,
b) household off-farm employment;

HHHCAP = household human capital stock:
a) age of head of household,
b) literacy status of head of household, spouse;

LOCATION = department (as a proxy variable);

CREDIT = received credit last year (1 = yes);

SERVICES = received agricultural extension services last year (1 = yes).

The model postulates the following hypotheses:

a) Size of cropland available (rather than farm size) may be important for some crops, particularly to capture economies of scale.

b) The availability of household labor for on-farm employment determines shifts among crops with different labor intensity, particularly shifts to potatoes and vegetables, which are more labor intensive than maize and wheat.

c) Economic returns to the household are equated at the margin between on-farm and off-farm employment opportunities; relatively high-wage, secure off-farm employment (business or permanent employment) competes with on-farm employment in more labor-intensive crops.

TABLE 4

HOUSEHOLD MEMBERS WITH OFF-FARM REMUNERATED EMPLOYMENT, BY CROPLAND EXTENSION CLASS, WESTERN HIGHLANDS, 1987 (Weighted Percentages)

	ALL				≤.5 ha				>.5 ha			
HOUSEHOLD MEMBER	MF	PF	WF	VG	MF	PF	WF	VG	MF	PF	WF	VG
Male head	49.2	63.9	40.7	25.6	51.2	80.6	52.4	20.0	45.5	55.6	35.8	29.9
Female spouse	3.1	6.5	5.5	.9	3.5	6.4	9.6	.0	2.2	6.4	3.8	1.5
Children	20.0	26.7	19.0	11.2	15.1	19.4	14.3	4.0	30.0	30.2	20.8	16.4

NOTE.—MF, maize farmers; PF, potato farmers; WF, wheat farmers; VG, vegetable growers.

d) Households with more human capital stock (here age of head of household and literacy are proxy variables) are more likely to diversify because of reduced risks.

e) Farm location is important in the diversification process because of such location-specific variables as access to markets (for hired labor, inputs, farm products), soil and ecological conditions, and so forth.

f) Access to credit facilitates the diversification process by financing higher production costs (infrastructure, labor, farm inputs), while access to agricultural extension services provides knowledge about growing and marketing new crops; thus both reduce the risk of adoption of new production techniques.

The probit model was formulated in order to contrast potato and wheat farmers and vegetable growers with maize farmers in three separate comparisons. The results of the model estimations are presented in table 5. When smallholder farmers received credit or had access to agricultural extension services they were more likely to be potato farmers rather than maize farmers, by 21% and 27%, respectively.[12] But if someone in the household was employed as a day laborer, or if the spouse was literate, the household was less likely by 22% and 31%, respectively, to be engaged in potato production in addition to maize. Smallholder farm households located in the departments of San Marcos and El Quiché, compared with farm households located in the department of Sololá, were less likely to be potato farmers by 52% and 59%, respectively.

Access to credit increases the likelihood by 42% that a smallholder farmer produces wheat rather than just maize and/or beans. Household labor supply constraints and access to credit seem to be major factors associated with crop diversification based on vegetable production, by 13% for each household member over 10 years old present in the household and by 16% when the farmer received credit. On the other hand, if someone in the household had a permanent off-farm job, the household was less likely by 22% to be engaged in vegetable production. Also, if someone in the household was engaged in a business enterprise or if the farm household was located in San Marcos (instead of in Sololá) the household was less likely by 15% and 30%, respectively, to be engaged in vegetable production.

It is clear that access to credit is an important factor associated with crop diversification; household labor supply constraints and alternative off-farm employment opportunities, as well as location, are important, too. On the other hand, farm size and household human capital stock do not appear to play a role.

Crop Commercialization and Household Income

It has been shown elsewhere that crop diversification in Guatemala based on export vegetable production increases substantially the net

TABLE 5

Probit Models to Estimate Determinants of Diversified Crop Patterns among Smallholder Farmers, Western Highlands, 1987

Independent Variables	Potato Farmers	Wheat Farmers	Vegetable Growers
VAR 1	.069 (1.84)**	−.017 (.91)	−.008 (.62)
VAR 2	.217 (1.23)	.100 (.73)	.317 (2.42)*
VAR 3	.399 (1.24)	−.119 (.48)	−.376 (1.75)**
VAR 4	.008 (.00)	−.127 (.50)	−.542 (2.58)*
VAR 5	−.137 (.56)	−.061 (.29)	.045 (.22)
VAR 6	.541 (2.25)*	−.019 (.09)	.393 (2.17)*
VAR 7	.001 (1.18)	.001 (.57)	−.001 (.10)
VAR 8	.306 (1.38)	.005 (.03)	−.126 (.68)
VAR 9	−.782 (2.53)*	.138 (.65)	−.003 (.02)
VAR 10	.536 (2.16)*	1.051 (3.61)*	.748 (3.34)*
VAR 11	.668 (2.57)*	−.006 (.02)	−.174 (.74)
D1	1.910 (1.19)	.151 (.13)	.848 (1.00)
D2	.790 (1.58)	.003 (.01)	−.254 (.51)
D3	−1.308 (2.59)*	.101 (.22)	−.740 (1.80)**
D4	.416 (.89)	−.247 (.49)	.068 (.16)
D5	−1.476 (2.81)*	−5.700 (.02)	.189 (.46)
Constant	−.599 (.51)	.734 (.60)	−.150 (.14)
χ^2	171.18	52.49	85.43
($P < \chi^2$)	(.0001)	(.0001)	(.0001)

Note.—Coefficient = probit estimate; *t*-ratio is in parentheses. VAR 1: cropland extension under cultivation; VAR 2: no. of household members >10 years of age; VAR 3: a household member employed off-farm: business; VAR 4: a household member employed off-farm: permanent salaried work; VAR 5: a household member employed off-farm: cottage industry; VAR 6: a household member employed off-farm: day laborer; VAR 7: age of head of household; VAR 8: literacy status of head of household; VAR 9: literacy status of spouse; VAR 10: received credit last year (1 = yes); VAR 11: received agricultural extension services last year (1 = yes); D1: Totonicapan; D2: Quetzaltenango; D3: San Marcos; D4: Huehuetenango; D5: El Quiché.

* $P < .05$.

** $P < .10$.

return to land.[13] Data for 1986 obtained from the National Bank of Agricultural Development show that in the western highland regions the gross margins/hectare (adjusted for vegetation period) of different crops were on average a multiple of the gross margins for maize.[14] On these grounds, we expect that maize farmers have comparatively lower farm incomes than potato and wheat farmers. At the same time, potato farmers were more often, and vegetable growers less often, engaged in off-farm employment, which should reduce the income differentials among the four groups.

The weighted medians of per capita income, by farmer group and cropland extension class, are presented in table 6.[15] Weighted by within-group crop-mix distributions and cropland extension class, the largest overall income differential was between wheat farmers and maize farmers, and the smallest between potato farmers and maize

TABLE 6

LEVELS AND DISTRIBUTIONS OF PER CAPITA MONTHLY INCOME, BUDGET SHARES OF FOOD AND NONFOOD EXPENDITURES, AND VALUE OF HOUSEHOLD CONSUMPTION OF OWN-PRODUCED FOODS OF SMALLHOLDER FARM HOUSEHOLDS, BY CROP AND EXTENSION CLASS, WESTERN HIGHLANDS, 1987 (Weighted Medians)

	All				≤.5 ha				>.5 ha			
	MF	PF	WF	VG	MF	PF	WF	VG	MF	PF	WF	VG
Per capita monthly income:												
Quetzales*	47.3	51.0	58.2	54.7	45.8	41.7	59.7	54.6	50.0	55.2	57.7	54.9
% difference with maize farmers	. . .	7.8	23.0	15.6	. . .	−9.0	30.3	19.2	. . .	10.4	15.4	9.8
Gini-coefficient	.27	.33	.27	.30	.26	.29	.23	.29	.26	.34	.28	.30
Per capita food expenditures:												
Quetzales	20.0	19.4	23.0	21.2	19.6	15.8	25.1	20.7	20.6	21.0	22.4	21.4
% of income	42.3	38.0	39.5	38.8	42.8	37.9	42.0	37.9	41.2	38.0	38.8	39.0
Per capita nonfood expenditures:												
Quetzales	25.9	26.9	30.8	30.5	25.3	23.2	32.0	31.0	26.7	28.5	30.6	30.0
% of income	54.8	52.7	52.9	55.8	55.2	55.6	53.6	56.8	53.4	51.6	53.0	54.6
Value of own-produced food:												
% of income	2.9	9.3	7.6	5.4	2.0	6.5	4.4	5.3	5.4	10.4	8.2	6.4

NOTE.—MF, maize farmers; PF, potato farmers; WF, wheat farmers; VG, vegetable growers.
* Quetzal = US$.40 (in 1987).

farmers. Among wheat farmers and vegetable growers, the relative income differences were the largest among the smallest farms, while potato farmers in this cropland extension class suffered lower incomes. Potato farmers and vegetable growers, particularly those with large farms, exhibited greater disparity in income distributions than did maize and wheat farmers. The disparity in income distribution among the smallest wheat farmers was actually lower compared with maize farmers in the same cropland extension class. Crop diversification based on potato production may thus increase the economic vulnerability of smallholder farmers, especially among those with the least cropland, leading to frequent off-farm employment by potato farmers' households.

Households in the four farmer groups overall spent similar amounts on food. The food budget shares ranged from 42% for maize farmers to 38% for potato farmers and were lower among maize and wheat farmers with larger cropland extensions. The food budget shares appear to be low for these low-income households. Household consumption of own-produced food crops constituted a minor source of income: 3% for maize farmers versus 5%–9% for diversified farmers. As a share of total income, household consumption of own-produced food crops was generally higher among farmers with larger cropland extensions; this was true for both maize and diversified farmers. Food expenditures seemed generally to be quite unresponsive to positive income differences across farmer groups. Lower food expenditures were associated with the negative income difference between potato and maize farmers with less than 0.5 hectares in cropland. This suggests that the smallest potato farmers' households were possibly the most vulnerable to low food availability among all farmer groups, even when taking into account the differences in the income share in the form of consumption of own-produced foods (table 6).

Crop Commercialization and Household Food Availability

As previously indicated, it is often assumed that the food security of smallholder farm households is negatively affected by crop commercialization because of decreased or more volatile household income levels and displacement of food crops by cash crops. The income issue was dealt with in the previous section, and here we will deal with the food crop displacement issue and with the joint effect on household food availability (as measured by daily dietary energy and protein intakes).

Results from previously cited studies (see n. 5) suggest that yield increases in staple food production associated with commercial crop production offset the negative impact of reduced land allocation. If, in addition, the share of household-produced staple foods set aside for household consumption remains unchanged, then household food supplies should not be negatively affected. We found that all crops were highly commercialized, but particularly so vegetables (79%–99%) and potatoes (88%–93%). The household consumption share of own-produced maize was lower among diversified farm households (20%–24%) than among maize farmers (33%), while it varied for beans among diversified farmers (39%–52%) compared with maize farmers (43%). The percentage allocated for household consumption was lower on larger crop extensions for all crops, except for red beets and carrots. Given these group differences in the consumption share of own-produced crops, in yields and in land allocation pattern, next we examined the net differences in per capita consumption by different crops.

Potato farmers and their households who grew maize consumed slightly less own-produced maize than maize farmers and their households (table 7). This difference was more pronounced among farmers with more than half a hectare in crops (26%), reflecting a difference in percentage of land allocated to maize (35%) and in percentage of production allocated for household consumption (18%), partially offset by a difference in maize yields (19%). Maize farmers and their households consumed more own-produced maize and beans with larger crop extensions. These differences were considerably smaller for potato farmers' households, who consumed significantly more potatoes from own production with larger cropland extensions.

Wheat farmers and their households who grew maize consumed overall more own-produced maize (18%) than maize farmers, with a significant greater difference (28%) among those with less than 0.5 hectare in cropland. Maize yield differences were greatest on larger farms (49%), but wheat farmers with small crop extensions allocated a larger share of the maize crop for household consumption than did maize farmers, while the opposite was found among farmers with larger crop extensions.

The households of vegetable growers consumed considerably less own-produced maize than maize farmers and their households did. In addition to sharp reductions in the share of cropland allocated to maize production, these households also allocated significantly smaller shares of maize production for household consumption. As indicated before, only among farmers with larger extensions was there a small maize yield difference with maize farmers. Vegetable growers who grew potatoes consumed significantly less of their own production than potato farmers. Consumption of own-produced beans was higher among vegetable-growing households with small farms than among maize farmers in the same cropland extension class. Vegetable growers with small cropland extensions consumed more of their own-produced vegetables (with the exception of cauliflower) than growers with larger extensions. Higher yields (with the exceptions of broccoli and cabbage), larger shares of production allocated for household consumption

TABLE 7

PER CAPITA CONSUMPTION OF HOUSEHOLD-PRODUCED CROPS (lbs/year) BY SMALLHOLDER FARM HOUSEHOLDS, BY CROPLAND EXTENSION CLASS, WESTERN HIGHLANDS, 1987 (Weighted Medians)

	ALL				≤.5 ha				>.5 ha			
CROPS	MF	PF	WF	VG	MF	PF	WF	VG	MF	PF	WF	VG
Maize	67.4	63.2	79.5	55.6	59.1	59.3	75.5	38.3	84.4	65.0	80.8	64.8
Beans	7.9	6.0	6.6	7.9	5.4	6.0	8.5	7.6	9.8	6.0	5.7	8.0
Potatoes	...	69.3	55.1	34.9	...	53.6	90.3	39.5	...	76.6	47.6	32.2
Wheat	...	...	2.0	...	...	...	4.6	...	...	...	1.9	...
Broccoli	...	...	...	1.1	...	...	...	3.0	...	...	...	.8
Cauliflower	...	...	...	8.2	...	...	...	7.9	...	...	...	8.5
Cabbage	...	...	...	3.7	...	...	...	6.1	...	...	...	2.4
Red beets	...	...	...	18.7	...	...	...	24.4	...	...	...	16.1
Carrots	...	...	...	36.7	...	...	...	51.7	...	...	...	25.4

NOTE.—MF, maize farmers; PF, potato farmers; WF, wheat farmers; VG, vegetable growers.

(with the exception of carrots), and larger shares of cropland allocated for vegetable production (with the exception of broccoli) contributed to these consumption differences between smaller and larger vegetable growers.

Household consumption of own-produced maize was found to be moderately responsive to fluctuations in production (holding per capita food expenditures constant) among maize farmers and vegetable growers (and not at all among potato and wheat farmers)—the elasticity coefficients were .30 and .35, respectively. However, household consumption of own-produced beans was found to be more responsive in all four groups—.51 among maize farmers versus .48–.68 among diversified farmers. We found no consistent evidence that agricultural extension services had a positive effect on the household consumption of own-produced food crops.

Total household food availability was measured by the daily dietary energy and protein intake levels, adjusted for household size and age and gender composition (adequacy level), as explained in the "Methods" section above. Energy intake levels are compared here to average recommended daily allowances and not to actual energy expenditure levels. If crop diversification is associated with above-average daily energy expenditure levels by household members (as has been suggested elsewhere) through the substitution of on-farm work for off-farm activities, then the comparative analysis here may well underestimate the energy deficiency status of diversified farm households. We also include the energy and protein intake levels of preschool children (12–60 months old). Their daily energy requirement levels are not likely to vary across different crop-mix patterns. Among the four groups potato farmers' households appeared to be the most vulnerable to inadequate daily energy intakes (table 8). The household energy intake status of the three remaining groups were quite similar. Daily protein intakes were less of a problem among these households in general, but households of potato farmers were relatively more vulnerable to inadequate protein intakes (26% vs. 15%–20% for the other groups).[16]

Preschool children were at significantly higher risk of inadequate daily energy and protein intakes, particularly children of potato farmers. Preschool children in general are more vulnerable to food insecurity than the households they belong to; among three-fourths of those households (minus preschoolers) which adequately met their recommended daily energy allowances, the preschooler did not.[17] This phenomenon was most often present in the potato farmers' households (84%) and tended to decline with farm size in all four groups but most notably among households of wheat farmers and vegetable growers.

In order to understand the factors that increase or decrease the risk of highland households and preschoolers having inadequate di-

TABLE 8

Dietary Energy and Protein Intakes of Smallholder Households and Preschool-Age Children (12–60 Months), Western Highlands, October–November 1987 (% Distribution)

Adequacy Levels	MF		PF		WF		VG	
	Household	Preschooler	Household	Preschooler	Household	Preschooler	Household	Preschooler
Dietary energy intake:								
<80%	16	54	22	74	15	55	16	57
80%–100%	23	24	33	13	24	24	23	18
>100%	61	23	45	13	62	21	61	24
Protein intake:								
<80%	6	25	7	23	8	26	4	23
80%–100%	10	15	18	25	12	16	9	11
>100%	84	60	74	52	80	58	87	66

Note.—MF, maize farmers; PF, potato farmers; WF, wheat farmers; VG, vegetable growers.

etary energy and protein intakes, two probit models were formulated and estimated. The household model specifies as the dependent variable the adequacy of daily energy intake (1 = below 90% of recommended daily allowances [RDA]) or of protein intake (1 = below 100% of RDA). The independent variables are per capita income (terciles of the overall distribution), household size class, consumption of own-produced foods as a share of total income, food expenditure share of total income, and farmer group (comparing potato, wheat, and vegetable growers with maize farmers). The results are presented in table 9. Households with per capita incomes in the middle or upper tercile of the overall distribution were less likely on average to be energy deficient by 7% and protein deficient by 12% than households in the next lower tercile. This shows that household energy and protein intake levels are generally not very responsive to income changes among these households.

Potato farmers' households were more likely to be energy deficient than other households by 11%, and protein-deficient by 13%. The income share of own-produced foods and food expenditure share, over

TABLE 9

PROBIT MODELS TO ESTIMATE DETERMINANTS OF ADEQUATE DIETARY ENERGY AND PROTEIN INTAKES OF SMALLHOLDER FARM HOUSEHOLDS AND PRESCHOOL-AGE CHILDREN, WESTERN HIGHLANDS, 1987

Independent Variables	Household		Preschooler	
	Dietary Energy	Protein	Dietary Energy	Protein
VAR 1	−.163 (2.44)**	−.308 (4.06)*	...	...
VAR 2	...	...	−.020 (2.90)*	−.001 (.66)
VAR 3	.054 (.43)	−.194 (1.38)	−.490 (2.42)**	−.400 (2.38)**
VAR 4	...	...	.132 (.88)	−.083 (.57)
VAR 5	.266 (.95)	−.068 (.21)	.247 (.65)	.583 (1.34)
VAR 6	.003 (.40)	.014 (1.43)	...	...
D1	.286 (2.26)**	.330 (2.39)**	.311 (1.76)***	.196 (1.20)
D2	.031 (.20)	.246 (1.49)	.003 (.01)	.157 (.79)
D3	.100 (.73)	−.036 (.23)	−.027 (.15)	−.115 (.63)
Constant	−.820 (1.47)	−.568 (.92)	1.502 (2.59)*	−.220 (.42)
χ^2	16.19	28.55	19.12	14.63
$(P < \chi^2)$	(.023)	(.002)	(.008)	(.041)

NOTE.—Numbers are coefficients; t-ratios are in parentheses. VAR 1: 1, 2, 3 terciles of the overall per capita income distribution; VAR 2: per capita food expenditures/month; VAR 3: household size "1," <5 members, "2," ≥5 members; VAR 4: mother's literacy status "1," yes, "0," no; VAR 5: self-consumption share in total income "0," =0, "1," >0; VAR 6: percentage of food expenditures/total income; D1: dummy variable; potato farmer "1," else "0"; D2: dummy variable: wheat farmer "1," else "0"; D3: dummy variable: vegetable grower "1," else "0."

* P <.01.

** P <.05.

*** <.05 < P <.10.

and above per capita income levels, as well as household size did not change the risk that households are energy or protein deficient. At the same time, households of wheat farmers and vegetable growers were not less likely to be energy or protein deficient than those of maize farmers. The income variable in the model may capture the differences related to crop mix; but when the models were run without the income variable, the same results with respect to farmer group differences were obtained.

A different probit model was formulated and estimated for preschool children. The dependent variables are defined the same way as for the household model. The independent variables were per capita food expenditures, household size, mother's literacy, income share in the form of consumption of own-produced foods, and farmer group (contrasting each group with maize farmers).

For every quetzal increase in monthly per capita food expenditures, the risk that the preschoolers' food intake was energy deficient was reduced by 1%. Preschoolers from larger households were less likely to have energy-deficient (by 20%) and protein-deficient (by 16%) daily food intakes. The household size effect may partially capture an income effect or may indicate that in larger rural households labor is less restricted, allowing more child care, including more adequate feeding of preschool children. Preschool children were also more likely (by 12%; $P < .08$) to have energy-deficient food intakes when they belonged to households of potato farmers.

Conclusions

Diversified farm households were indeed more market dependent, but the maize farmers also commercialized a significant share of their maize production. The comparisons here do not so much involve complete transformations from subsistence to cash crop farming but, rather, partial substitutions among crops that were commercialized in different degrees by market-integrated farmers. The net income-effect of crop substitutions depends on the relative net returns of the different crops and on the degree of crop substitution. Average figures on relative gross margins indicated that positive farm income differentials can indeed be expected from diversification and, in fact, suggest that crop specialization may produce still larger and positive net income differences. However, those gross margins are likely to be subject to considerable intertemporal and interspatial variation. Lack of market access, fluctuating farm output and input prices, even market failures as well as inefficient marketing institutions, can reduce gross margins significantly and produce income losses. As the results indicate, access to credit continues to play a major role in the diversification and commercialization process, allowing smallholder farmers to assume the greater risks associated with commercial crop production. To raise the incomes of the smallest farmers in a significant and sustainable way will require the targeting of these farmers for: (*a*) credit (changing current selection criteria), (*b*) agricultural extension services (which more appropriately take into account the resource constraints these farmers face), and (*c*) better market access and more efficient marketing services. Promotion of small farmer organizations that vertically integrate production, processing, and marketing may strengthen income gains and reduce income disparities among smallholder farmers.

Positive per capita income differentials were found for wheat and vegetable growers compared with maize farmers. The largest relative income differences were among the smallest wheat and vegetable farms, a finding that is consistent with the conclusions from the Guatemala export vegetable crop study.[18] The disparity in income distribution among diversified farmers may increase somewhat overall but remains unaffected or may decrease among the smallest farmers. However, the smallest potato farmers appear to be at some risk of relative income losses. The reasons for this remain to be explored. But the fact that these farm households have the greatest need to engage in off-farm employment underscores the risk of lower incomes. Lack of access to major potato markets and inefficient marketing institutions may be contributing factors.

A second issue deals with increased vulnerability to reduced food availability from own production. The findings indicated that indeed greater vulnerability to lower availability of household-produced food was present in the following cases: (*a*) maize consumption among potato and vegetable growers compared with maize farmers, and (*b*) potato consumption among wheat and vegetable growers compared with potato farmers. Diversified farmers may have had more types of own-produced foods available for consumption, leading to partial substitution of own-produced foods for maize and beans. But among these farmers their own production was a relatively minor source of food for household consumption, and increases in production can be expected to produce less than proportional increases in household consumption. Thus, per capita food expenditures and market prices take on added importance for the food security of market-integrated farm households. The income–food expenditure and the income–dietary energy intake relationships at both household and individual levels were generally weak in all farmer groups. These findings are consistent with those reported elsewhere.[19] Greater control by male household members over income generated through commercial crops and purchased food baskets that contain higher-priced food items at higher income levels are among the arguments often advanced to explain these findings. Repayment of high-interest, informal loans and greater cash needs associated with commercial crop production may contribute to keeping household food budgets low. High commercialization rates of basic food crops may also be indicative of this problem. Access to rural savings and credit institutions that earn farmers' confidence may contribute to raising household food budgets and thus household food security.

The smallest potato farmers and their households appear to be the most vulnerable to inadequate energy and protein intakes, while households of wheat farmers and vegetable growers are generally not better off than maize farmers' households despite substantial income differentials. Preschool children are, relative to the households they belong to, more vulnerable to inadequate energy and protein intakes and increasingly more so the more the household food supply is constrained. Significantly higher household food budgets are likely to result in more adequate food availability for preschool children, which in turn argues for sustained reductions in rural poverty.

We conclude that the previously signaled negative household effects associated with crop commercialization among smallholder farmers seem to apply to the smallest potato farmers but not to wheat farmers and vegetable growers or to potato farmers with larger farms. At the same time, no significant improvements in household and preschooler food security seem to be associated with higher incomes generated through commercial crop production by smallholder farmers.

Notes

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11. The group medians were weighted by the relative proportions with which each crop mix and cropland class occurred within each farmer group. This same approach was used in much of the following analysis.

12. The probit estimates from the models, multiplied by 0.4 become approximate linear probability estimates. T. Amemiya, "Qualitative Response Models: A Survey," *Journal of Economic Literature* 19 (1981): 1483–1536

13. von Braun, Hotchkiss, and Immink. The vegetables in question were snow peas, broccoli, and cauliflower.

14. Wheat, 160%; beans, 280%; potatoes, 780%; and vegetables, 1,360% (average for broccoli, cauliflower, cabbage, red beets, and carrots).

15. Income was measured as the sum of food and nonfood expenditures and the market value of food consumed from own production, using average market prices at the time of the study. A nonparametric test of unweighted group medians of per capita income indicated a significant overall difference among the farmer groups (χ^2 12.12; $P < .01$) and between maize farmers and potato farmers (χ^2 4.68; $P < .05$), wheat farmers (χ^2 8.92; P .01), and vegetable growers (χ^2 7.16; $P < .01$).

16. It should be kept in mind that the food intake measurements were made at the time when staple foods (maize) were being harvested. The analysis leaves out micro-nutrient intakes and dietary diversity as important dietary outcome variables. Preliminary analysis indicates that of seven micro-nutrients calcium and riboflavin were the most limited in household diets, while iron, vitamin A (retinol), niacin, and vitamin C were limited to a lesser degree. The results of Scheffé's multiple range test indicate that potato farmers' households had significantly lower vitamin A and significantly higher vitamin C intakes compared with those of other households ($P < .05$). No significant differences among the farmer groups in other micro-nutrient intakes were found.

17. In addition to the measurement errors inherent in the 24-hour recall method, recommended daily energy and protein allowances may overstate somewhat the children's actual energy and protein needs due to their smaller size as compared to healthy children. The general conclusion, however, is not seriously affected by these considerations.

18. von Braun, Hotchkiss, and Immink (n. 5 above).

19. See, e.g., Bouis and Haddad (n. 5 above).