100

ADOPTION OF HYBRID MAIZE IN ZAMBIA: EFFECTS ON GENDER ROLES, FOOD CONSUMPTION, AND NUTRITION

Shubh K. Kumar

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CONTENTS

TABLES

ILLUSTRATIONS

FOREWORD

Enhanced agricultural productivity in Sub-Saharan Africa is critical to promote economic growth and poverty alleviation and to avoid increasing food scarcities in the region. The impact of commercialization and intensification of agriculture on the well-being of the rural poor depends on how they are carried out. Past research by IFPRI and collaborating institutions on commercialization of small-scale farming in about a dozen countries provided new knowledge about the relationships between commercialization and rural well-being as measured by incomes, consumption, and nutrition. These links were shown to depend greatly on household behavior, which in turn is influenced by intrahousehold processes. A better understanding of these processes is likely to identify policy measures that will be effective in achieving both productivity and household welfare goals.

This report contributes to improved understanding by examining household and intrahousehold processes influencing the welfare effects of the adoption of hybrid maize among farmers in a region of Zambia. The report identifies a number of key policy options likely to be central to achieving higher agricultural productivity and improved rural welfare simultaneously.

While extending previous research on agricultural commercialization and technological change in several countries, the research reported here is a part of a larger collaborative research project undertaken with the University of Zambia, Rural Development Studies Bureau, and the Zambian National Food and Nutrition Commission. Several other IFPRI reports are available from this project, including an occasional paper, *Adopting Improved Farm Technology: A Study of Smallholder Farms in Eastern Province, Zambia*, edited by Rafael Celis, John T. Milimo, and Sudhir Wanmali, and Research Report 94, *Fertilizer Use on Smallholder Farms in Eastern Province, Zambia*, by Dayanatha Jha and Behjat Hojjati. Past research on commercialization of small-scale agriculture is synthesized in a book published for IFPRI by the Johns Hopkins University Press, *Agricultural Commercialization, Economic Development, and Nutrition*, edited by Joachim von Braun and Eileen Kennedy.

Per Pinstrup-Andersen
Director General

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1

SUMMARY

This report examines the role of hybrid maize adoption in Eastern Province, Zambia, in improving the welfare of the population. Improving agricultural productivity of farmers in Zambia is important for the success of the country's new economic growth strategy, and past investment in hybrid maize research has developed a potential for increased productivity that needs to be fully utilized.

Maize is the single most important food in the Zambian diet, and its primacy has grown steadily as the result of past government policies that encouraged the production of maize in all parts of the country, including areas where it may not be economically efficient to grow maize. Given current market liberalization efforts, it is likely that maize production in general and marketed maize production in particular will remain viable only in areas near the major population centers because of transport costs. Such a contraction in maize area would increase the need for improved technologies to raise agricultural productivity in outlying areas in order to maintain their current level of income. Since most of the previous agricultural research in Zambia has been on maize, this crop offers more options for increased productivity than other crops. However, even if other crops are promoted, the experiences in optimizing growth and welfare outcomes with hybrid maize should be useful.

Until the late 1980s, aggregate increases in maize production were limited, despite a substantial expansion of hybrid maize adoption and fertilizer use. Since then, a wide range of improved maize varieties suitable for small farms has been released by agricultural research stations in Zambia. The potential thus exists for rapid improvements in productivity, income, and welfare.

This report examines farm household-level factors that influence the adoption of hybrid maize in Eastern Province and the implications of adoption for improvement in household income, food consumption, and nutrition and health of the rural population. The characteristics of adoption, such as who adopts and what other changes are associated with it, in particular its implications for household labor allocation and intrahousehold access to resources, are expected to influence food consumption and the nutritional status of the population.

The analytical approach is geared to trace the distributional and welfare consequences of hybrid maize production. An instrumental variable approach is used to make predictions on the effects of hybrid maize adoption. Previous IFPRI work has generally shown that incomes rise with the adoption of improved agricultural technologies, but child nutrition does not necessarily improve. In this report, the implications of a wide range of resource allocation decisions that are associated with adoption and that influence the distribution of welfare improvements are examined. These include changes in women's access to resources and decisionmaking, labor allocation decisions, and characteristics of cash flow and allocation of income. Area-level characteristics such as access to infrastructure and markets and geographical variation in adoption rates are also considered. Although the analysis identifies adoption of hybrid maize production as a key element of technological change in agriculture, adoption is nearly always accompanied by increased use of chemical fertilizers and an expansion of cultivated area associated with a shift from hoe to ox-plow use.

This report is based on a collaborative study in Eastern Province conducted in 1986 by the International Food Policy Research Institute, together with the University of Zambia's Rural Development Studies Bureau and the Zambian National Food and Nutrition Commission, to examine the growth and equity effects of technological change in agriculture. Results of this study were presented to the government of Zambia between 1987 and 1990, and this report presents a detailed analysis of those results.

Eastern Province is one of the major agricultural regions of Zambia; it consistently produces large maize surpluses. Its predominantly rural population depends on agriculture for nearly 80 percent of its income. Agriculture is mainly smallholder, with an average farm size of 2-3 hectares. It has some of the best agricultural land in the country, but, as in many other parts of Africa, it has a single rainy season, thus providing only one main growing season for farmers.

Study sites, located in each of the districts, were selected to provide a representative sample of households from the province and its two main ecological zones—plateau and valley. During 1986, 330 households, drawn from a stratified random sampling, were visited monthly and interviewed on agricultural production practices, labor allocation, off-farm income sources, food and nonfood consumption, morbidity, and intrahousehold decisionmaking. In addition, weights and heights of each household member were recorded four times during the year to determine anthropometric status and hence nutritional status.

Among the 10 percent of farmers with the largest farms in Eastern Province, nearly all with more than 5 hectares adopted hybrid maize. However, adoption was also substantial among the smaller farms, with about 50 percent of those in the 3-to-5-hectare category, 37 percent in the 2-to-3-hectare category, and 25 percent in the 1-to-2-hectare category adopting hybrid maize. Data indicate, however, that hybrid maize production is more profitable for smaller farms. Marginal improvements in income deteriorate beyond 4 hectares under hybrid maize. This implies that policies directed to adoption by larger farmers may be contributing to lower productivity gains from this technology.

Because it is harder to process and store hybrid maize, farmers also grow local maize for home consumption and sell most of the hybrid maize. Where labor supplies are short, farmers are likely to devote more attention and resources to local maize. Policy measures to improve local storage and processing options could further improve hybrid maize productivity because these measures would shift its place in the cropping system from cash crop to food crop, so that farmers would give it priority in timing of planting and other operations. The market liberalization now under way should provide an incentive for investments in low-cost rural storage improvements, for which technologies already exists. Improvement in rural infrastructure will also be critical.

Female-headed households have a lower adoption rate for hybrid maize (22 percent) than male-headed households (34 percent). However, the pattern varies across farm sizes. Female-headed households of less than 3 hectares have a lower adoption rate than larger farms headed by females, indicating that once women are able to overcome resource constraints, they are just as likely or even more likely to become technological innovators.

Women play an important role in agriculture in both female- and male-headed households. Overall, about half the cultivated area is either independently or jointly managed by women. This share is highest for local maize and traditional cereals (60 and 70 percent, respectively). Women have less involvement in hybrid maize than in any other crop, with only 25 percent of area being independently or jointly managed by women. Moreover, adoption of hybrid maize by a household tends to reduce women's share in crop management and agricultural decisionmaking, independent of farm size. This may be because women have less access to resources such as credit, inputs, and human resource improvements, which are essential for producing the new crop varieties, or it may reflect men's desire to control income from cash crops.

Overall, women provide nearly 60 percent of family labor in agriculture, but with adoption of hybrid maize, men tend to shift from nonagricultural activities to agriculture, thereby increasing their share of labor input. Although the amount of time that women spend in farm work is reduced with hybrid maize adoption, the time women spend on household maintenance activities increases.

The distribution of crop income within households reflects the extent of household members' participation in crop management. Therefore, women's share of income and the value of their time relative to men's declines with adoption of hybrid maize. The failure to use women farmers effectively, both in female-headed households and those headed by men, contributes to productivity losses by shifting women's labor away from farming activities.

Policies that support participation of women in decisionmaking and production of improved grain varieties not only could improve efficiency but could also improve household food consumption and children's nutritional status. Women's share of income and the time they spend in household maintenance activities are significantly positive factors in improving overall household dietary intake, but only women's income share is significant for improving child nutrition. This suggests that patterns of child care available are compatible with women's work in rural Zambia. The trade-off observed between women's work at home and household food consumption is very small in absolute terms and could be reduced with better access to improved technologies for household maintenance activities, such as hammer mills for grinding grain. With a larger share of income, women are better able to obtain access to such household maintenance improvements. For example, women themselves now pay for the majority of household food processing costs. Viewing women's maintenance and home production roles as simple trade-offs in family and especially child welfare is therefore not justified, given all the dynamics involved.

In examining household food intake, this study uses a modified food expenditure record to compute calories and protein consumed. Micronutrients analyzed include iron, calcium, and vitamins B_1, B_2, and B_3, all of which are important in energy metabolism. Diet diversity is also measured. Results indicate that areas that have a high level of adoption of hybrid maize also have a higher level of food intake than areas of low adoption. Looking at the household level, however, with adoption of hybrid maize, intakes improved only for the smaller farmers. The larger farmers who adopted hybrid maize actually had *lower* consumption of nutrients. This finding is consistent with the limited profitability found beyond 4 hectares of hybrid maize planted. This adoption pattern helps reduce income inequality between small and large households, while increasing income inequality within large farm households. Decisions on household food consumption and income are closely interrelated, which is plausible in a farming system facing pronounced seasonal labor shortages, where farmers cannot provide the necessary labor if the supply of food available is insufficient to maintain their energy. If they sell their food crops to increase income, their food supply falls. Similarly, if they denote more labor to the cash crop, the food crop will suffer. Measures to improve food consumption are therefore likely to be as effective as measures to improve income in making sustainable changes in welfare.

Analysis of the nutritional status of children shows both household income and women's income to be significantly positive for the longer-term nutrition indicators, such as height-for-age, but women's time spent on household maintenance activities is not significant and contributes more to short-term nutrition improvement. Whether a male or a female headed a household was not a significant factor in improving child nutrition: who manages the crop and therefore allocates the income from it is the important factor. Better access to health services and improved sanitation facilities are significantly associated with improved child nutrition. Some catch-up growth in height between the ages of 5 and 10 years is indicated, and there is no difference in the nutritional status of boys and girls.

Efforts to promote productivity gains through better access to inputs by the smaller farmers, and to ensure access to physical and human resources by women including those in male-headed households, will be important if the full potential of new technologies for improving food production and welfare of the population is to be realized. The progress of new hybrids and composite varieties of maize in the farming system also needs to be monitored to ensure that they are being grown not only as cash crops but also as food crops and, therefore, receiving the same degree of priority as local maize. This will be facilitated by the effects of market liberalization on incentives for better on-farm storage for maize. Spread of small-scale food processing facilities should also have a favorable impact on the integration of improved maize varieties into the farming system. Other areas where policy attention is needed are the reduction in diet diversity and micronutrient intakes observed in areas with higher levels of adoption and the increase in welfare inequalities between high- and low-adopting areas.

2

RESEARCH AND POLICY ISSUES IN ADOPTION OF HYBRID MAIZE IN ZAMBIA

Agricultural growth in Zambia is increasingly recognized as central for sustained improvement in economic growth of the nation and food security and nutrition of the population. In the past, there was a pronounced urban bias in Zambia's development strategy, and this was reflected in lower levels of income and nutritional status in rural areas than in urban areas, a declining rate of agricultural growth, and high rates of rural-urban migration. This was accompanied by unsustainable growth of urban food subsidies and public-sector expansion. However, since the mid-1980s, Zambia has undertaken the difficult process of structural adjustment, with accompanying efforts to reduce public-sector control of agricultural prices and markets for both inputs and outputs. This process has raised the prospect of better incentives for agricultural production growth.

The need for technological change in Zambian agriculture is likely to be critical during this period of transition for several reasons. First, traditional agriculture relies primarily on area expansion for achieving growth, and this alone has limited potential for sustained growth. Second, the dismantling of public-sector control of pricing is likely to limit, geographically, the areas with a comparative advantage for producing marketed maize surpluses. Increased agricultural productivity will therefore be essential both for maintaining food supplies for the large urban populations and for expanding agricultural improvements and incomes across the country.

This report examines the nature and effects of technological change in maize production in Eastern Province, Zambia. It is primarily a study of impacts, and in the process, it also uncovers characteristics of adoption of new technology that may help clarify why adoption may have had a limited welfare benefit for households. In particular, the report focuses on changes in the intrahousehold dimensions of farm families—changes in women's role in crop management and their relative position in resource allocation of both money and time. In this process, a clearer picture of the intrahousehold changes that take place with adoption of new technology is drawn, and this is linked to both the policy environment and to welfare outcomes in terms of nutritional status.

It has been postulated that since women continue to play an important role in the production of household food crops in many parts of Zambia, agricultural growth programs and strategies need to ensure that women have access to resources and inputs. Absence of such measures may lead to limited success of growth measures and also failure to gain nutritional benefits from such growth. Earlier IFPRI studies in Kenya, The Gambia, and Rwanda on technological change and commercialization in agriculture have shown limited nutritional benefits from these efforts, even where income benefits for the household were noted (Kennedy 1989; von Braun, Puetz, and Webb 1989; von Braun, de Haen, and Blanken 1991). In this report, these associations are further examined to investigate the consequences of intrahousehold dynamics that reduce the relative decisionmaking role of women in the process of agricultural production while increasing the demand for women's time, especially in household maintenance activities. These dynamics are commonly observed during agricultural commercialization and can be traced to limited improvements in real household food security and nutritional status.

The challenge in proposing policy remedies for such dynamics is to examine both policy and cultural issues. Even though the effects of policies occur within the existing cultural context, policies and their institutional structures have a large responsibility in shaping the effects. In practice, the solutions need to emerge from within the communities affected. The choice for action, however, is with policymakers.

Importance of Maize Production

Although maize is only one of the many grain and root crop staples consumed by the Zambian population, it is overwhelmingly the favored staple food in urban areas. In rural areas, it is the main staple food in the central, southern, and eastern parts of the country (Table 1). Since these are the most densely populated parts of the country, maize emerges as the single most important food item in the Zambian diet. Although maize production has been encouraged in other parts of the country through a variety of public policy measures during the past six decades, other grains, such as finger millet, pearl millet, sorghum, and cassava, are still the predominant staples in the northern, western, and northwestern parts of the country.

Several historical factors have contributed to the spread of maize in Zambia. Diffusion of maize followed its introduction into the Congo basin around the sixteenth century. Maize, along with cassava, which was introduced about the same time, first appeared in the western and northwestern parts of the country and gradually spread eastward. However, in the early twentieth century maize received a big production boost with the opening of the interior of the country (then Northern

Table 1—Per capita consumption of basic staples and total calorie intake in rural areas, by province, 1980

Province	Maize	Cassava	Sorghum and Millet	Wheat and Rice	Total Calories per Day
	(kilograms/year)				
Central and Lusaka	171.1	4.0	19.2	17.0	2,103.4
Copperbelt	108.0	3.0	53.0	19.0	1,783.7
Eastern	143.0	0.6	6.5	2.2	1,524.2
Luapula	32.5	74.0	12.5	4.9	1,184.9
Northern	33.6	50.0	54.0	2.8	1,343.0
Northwestern	46.8	34.0	46.0	1.2	1,234.9
Southern	155.0	0.3	14.0	4.4	1,733.3
Western	90.3	28.2	13.0	2.6	1,365.2
Average	102.2	23.8	24.4	5.4	1,517.0

Source: Food and Agriculture Organization of the United Nations, *Zambia: Comprehensive Agricultural Development and Food Security Programme* (Rome: FAO, 1991), 21.

Rhodesia) to mining and settler interests. The earliest documented agricultural policy is that of encouraging European settler farmers to grow maize to supply food to mine workers (Dodge 1976). Gradually, some of these incentives were extended to the African farming communities close to the mining centers and along the original "line of rail." This line of rail has tremendous historical significance in the settlement pattern of Zambia. It is the train route that connects the mining areas in north central Zambia with ports in South Africa. Although a new line of rail has emerged with the opening of the Tazara line to Tanzania, the areas that lie along the original line of rail are still the best served infrastructurally.

Of the other staple food crops traditionally grown—sorghum, pearl millet, finger millet, and cassava—none has received the policy support given to maize. This is primarily due to the force of the urban demand for maize. By the early 1980s, nearly half of the country's population resided in urban and periurban centers, and maize dominated agricultural research and extension programs as well as the agricultural pricing and marketing policies of the government of Zambia. As a consequence, its importance in both agricultural production and in food consumption has grown steadily over time.

Technological Change in Maize Production

Growth in maize production during the past two decades is primarily due to area expansion. According to World Bank (1992) estimates, maize yields have declined by 2 percent annually, while area has expanded by about 11 percent, for a production growth rate of 8.5 percent during 1974-89. Much of the decline in maize yields is the result of the rapid expansion into relatively marginal areas encouraged by the agricultural production and extension policies.

Area expansion was fueled by a high growth rate of population (3.7 percent annually) and by some reverse migration during the period of structural adjustment. In addition to population growth, use of mechanical land preparation technologies such as ox-plow and tractor cultivation in the 1970s also encouraged expansion of area under crops. An abundant supply of land has facilitated the area expansion and, according to a World Bank analysis, "it has tended to encourage smallholders, who face a labor constraint, to substitute land for labor by adopting suboptimal crop husbandry practices (for example, single weeding under high fertilizer application)" (World Bank 1992, 31). Improved land preparation technology facilitates area expansion, only to impose a labor constraint on subsequent farm operations that are critical to raising yields. To some extent, farmers compensate for the labor shortage by increased use of improved seeds and fertilizers, but with a lower output response. To the extent that the availability of mechanical traction allows more land to be cultivated and makes it more likely that farmers will adopt the improved seed-fertilizer package, they can increase their net profitability despite the ensuing labor constraint (CIMMYT 1990, 34; Pingali, Bigot, and Binswanger 1987).

The yield-increasing technological changes available for maize production include improved varieties and modern inputs. Hybrid maize varieties have been available in Zambia since the 1960s, and were introduced to the smallholder sector around 1970. Reports available on growth in hybrid maize and other high-yielding varieties (HYVs) of maize are mixed. Aggregate yield increases, however, have been limited by expansion of maize area into ecological zones not considered suitable for maize production and by reduction of fallow in the more densely populated but suitable plateau zones.[1]

Hybrids and Other Improved Varieties

The most widely used hybrid maize is SR52, which was first introduced in Zambia for smallholder production in the late 1960s. Although other hybrids have been developed since then, none has matched the yields of SR52. Other hybrids that have been released include ZH1, SR11, ZCA, and SR13. Production of seed has, however, been sustained only for SR52, which accounted for 90 percent of commercial maize seed produced in 1980/81, and ZH1, which accounted for the remaining 10 percent in that year (Zambia Central Statistical Office 1981). Both of these varieties offer substantial yield advantages over the local varieties, especially in their response to fertilizer, but they are both long-duration varieties requiring 170 days to mature, which makes it critical to plant them early in the season.

More recently, Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT) has supported the development of high-yielding, open-pollinated composite maize varieties that are expected to reduce the annual cost and availability risks to farmers that are inherent in hybrid seed. Field trials on new composite varieties in the 1980s showed that they were not able to improve on the performance of the SR52. However, given that farmers do not have to buy seeds each year, they are still likely to be well received. Short-duration maize varieties are supposedly available but difficult to obtain in practice.

The progress in adoption is likely to be constrained by the seed production and distribution mechanisms available in Zambia. The Zambia Seed Company (ZAMSEED), a state-owned parastatal, is the only producer of improved seed, and it generally has not kept pace with the growth in demand for improved seed. During the 1970s, when growth in adoption was very rapid, seed availability increased only threefold (Zambia, Central Statistical Office 1981). Distribution of seed to producers is primarily through the National Agricultural Marketing Board (NAMBOARD), and in some provinces this function has been transferred by NAMBOARD to provincial cooperatives. In addition to the availability of improved HYVs of maize, agricultural extension and availability of credit and fertilizer are important factors in their adoption. As mentioned earlier, animal traction is a factor inasmuch as it allows area expansion, which, for various reasons, makes adoption of hybrid maize easier.

Progress in Adoption of Improved Maize Varieties

There is little reliable information on the adoption of improved crop varieties or other agricultural technologies in Zambia. Here, as elsewhere, use of improved maize germ plasm is difficult to estimate precisely because one cannot easily distinguish between improved and unimproved materials. As a consequence, tracing sources of seeds replaces visual inspection (CIMMYT 1990). According to CIMMYT sources, hybrids and other improved, open-pollinated varieties accounted for 64 percent of

[1]Yield reductions with continuous maize cultivation are especially pronounced in highly weathered soils such as those in northern Zambia, and occur despite fertilizer applications and soil pH control. Micronutrient depletion of the soil is a factor in this (SPRP 1987, 38).

maize area in 1985/86, but only 46 percent by 1988/89. Hybrids alone accounted for 53 percent and 45 percent of maize area, respectively, in those years (CIMMYT 1987, 1990). World Bank sources, on the other hand, indicate the share of maize area planted to hybrids increased from 47 percent in 1984/85 to 60 percent in 1988/89 (World Bank 1992). Given uncertainties such as these and lack of good national statistics on area planted to improved varieties, perhaps some idea about trends can be obtained from small-scale farm- and household-level surveys.

In the smallholder sector, hybrid maize was introduced in the late 1960s and began to take hold in the farming system very quickly. Its earliest adopters were, not surprisingly, the larger farmers in the traditional sector. A survey by Harvey (1973) in the Kalichero area of Chipata District, Eastern Province, in 1972 showed that about 7 percent of farmers grew hybrid maize and this accounted for less than 5 percent of maize area. All of the adopters were among the largest 15 percent of farmers.

Hybrid maize production grew rapidly during the 1970s. Fieldwork conducted by the author for the International Food Policy Research Institute in collaboration with the National Food and Nutrition Commission and the Rural Development Studies Bureau, University of Zambia, in 1981/82 showed that in the same part of the district surveyed by Harvey, 55 percent of the maize area was now sown in hybrids. At the same time, however, for Chipata District as a whole (including valley sites), the rate of adoption of hybrid maize (33 percent) was lower than that for Kalichero. The same study found a substantial decline in hybrid maize use in 1982—down to about 42 percent in share of maize area in the Kalichero sites.

In the present IFPRI survey in Eastern Province, the rate of adoption in Chipata District was about 23 percent of maize area in 1986, suggesting that there may have been a downward trend in HYV use there during the 1980s. This is consistent with the CIMMYT estimates and also with reports of declining maize yields from the World Bank.

Even though the study sites in the different surveys are not identical, the results from farm-level studies over the past two decades suggest that adoption of hybrids grew rapidly during the 1970s but stagnated or even declined during the 1980s.

The rate of adoption may be different in other parts of the country. Reports from provinces along the line of rail suggest that adoption grew more rapidly during the 1970s, especially in Central and Southern provinces as compared with Eastern Province (CIMMYT/GRZ 1978). There is also some indirect evidence that there has been rapid growth in adoption of hybrid maize as a rural cash crop in nonstaple maize areas. Primary emphasis on maize production, especially as a commercial crop, has been the focal point of agricultural extension and development efforts in all parts of the country, including some areas not considered suitable for maize cultivation (Wetterhall 1981; Evans 1981; Keller and Mbewe 1988). The most rapid growth in marketed maize production has been in areas where maize is not an important staple food and nearly the entire increment in production is likely to be marketed, as seen in Table 2 for Luapula, Northern, Northwestern, and Western provinces.

Factors Conducive to Adoption of Hybrid Maize

Agro-ecological Conditions. Most of the literature on Zambian agriculture clearly states that maize cultivation is not suitable in either the northern high rainfall or the western sandy areas. It is also in these areas that maize is not a primary staple food. Because agricultural price policy and agricultural extension emphasis has been

Table 2—Growth of marketed maize production, by province, 1973-89

Province	Marketed Production					Percent Change		
	Harvest Year					Harvest Year Range		
	1973	1977	1981	1985	1989	1973-81	1981-89	1973-89
Central and Lusaka	2,510	3,278	3,001	2,500	4,961	20	65	98
Copperbelt	132	70	37	242	484	–72	1,208	267
Eastern	501	942	1,184	1,781	2,471	136	109	393
Luapula	16	32	30	59	386	88	1,187	2,313
Northern	59	212	328	738	1,446	456	341	2,351
Northwestern	26	40	42	746	160	62	281	515
Southern	1,172	3,077	3,039	1,583	3,358	159	11	187
Western	15	86	43	92	285	187	563	1,800

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

on promoting maize production throughout the country,[2] however, adoption of hybrid maize has grown in all parts of the country.

Seed and Fertilizer Availability. Information on the seed industry in Zambia is scarce. ZAMSEED, a parastatal, provides very little information on the production and distribution of different varieties of maize seed. Available statistics indicate that SR52 is still the main variety. SR52 is a long-duration variety, requiring 170 days to mature, which may explain why its yields have been substantially lower in the smallholder sector. Because it requires early planting, it is well suited to commercial farms but not to traditional farms. Since farmers prefer to plant the plots that supply their food before planting hybrids, late planting of hybrid varieties is one of the main constraints to its productivity (CIMMYT/GRZ 1978). Varieties that are suitable for later planting, MM502, for example, give a similar yield and fertilizer response and may be more suitable for small-farm adoption (Central Province 1984). Demand for the short-duration varieties is strong, but their availability is poor (Keller and Mbewe 1988).

The distribution of improved seed and fertilizer is through NAMBOARD and the provincial cooperatives. The cooperatives primarily make inputs available to members who also have access to the cooperative's credit program. Nonmembers theoretically have access, but whether they receive inputs is likely to be a function of first meeting demand from members, the input supply situation, and cash availability.

Although fertilizer use in Zambia appears to have grown steadily during the 1970s and 1980s (Zambia, Ministry of Agriculture and Water 1983; World Bank 1992), the numerous problems with its distribution system have limited effective yield responses. Zambia imports the major part of its fertilizer supply[3] and channels the input through the parastatals (NAMBOARD and the provincial cooperatives). Problems with imports, the domestic distribution mechanism, and poor rural roads and storage have made timely availability of fertilizers a chronic problem.

[2]For example, a program of the 1980s called the Lima Crop Extension Program was aimed at improving the productivity of smaller farmers by assisting them in the efficient use of chemical fertilizer.

[3]Over two-thirds of nitrogenous fertilizers and all nonnitrogenous fertilizers are imports (FAO 1991).

Most analysts agree that the monopolistic nature of fertilizer marketing and distribution has contributed to the inefficiency of the system. During the 1992 harvest year, some licenses were being made available to private traders to market fertilizer, but mandated price subsidies may deter any substantial private involvement (FAO 1991). Seed distribution closely mirrors that for fertilizer. In this case, importation problems do not enter the picture; the main bottlenecks are inadequate production of improved varieties and the inefficient distribution mechanism. Available information suggests that seed production has lagged behind the development of short-maturing, open-pollinated varieties that are well suited to smallholder adoption (Keller and Mbewe 1988; CIMMYT 1990).

Improved Means of Cultivation. The traditional, low-tillage hoe cultivation method is still widespread in Zambia. Use of ox-driven plow cultivation, relatively recent, has been promoted in the country's agricultural growth strategy. The primary advantage of ox cultivation is that it makes it easier to plant a larger area (in a labor-constrained agriculture), and therefore it is considered essential for promoting the surplus production essential for commercialized agriculture.

There are still large parts of the country where ox cultivation is neither practiced nor feasible. The high-rainfall, northern areas raise cattle but, until recently, not oxen. In areas, including parts of Eastern Province, where tsetse flies carry the deadly trypanosome parasite, it is infeasible to maintain oxen or cattle. Hence, farmers in those areas only have access to hoe cultivation. In the 1970s, when the country's foreign exchange situation was relatively comfortable, there was an effort to promote tractor cultivation by local agricultural camps that would hire out tractors. By the 1980s, these had all fallen into disrepair, and the farmers in the traditional sector in tsetse areas again had no recourse but to use hoe cultivation.

To the extent that farmers in the smallholder sector plant HYV maize as a cash crop and depend on local maize or other staples for their food, use of ox-plow cultivation provides a means of expanding HYV production through area expansion. Numerous studies in Zambia and other countries in Sub-Saharan Africa have shown that increasing farm size allows farmers to expand cash crop production, while retaining as much acreage (or even more) for their own crop production. This is confirmed by studies in Zambia that show ox-plow users to be four-to-five times more likely to adopt HYVs than hoe cultivators, and they also plant a much larger area to the new varieties (ARPT/Eastern Province 1988).

Rural Infrastructure

In many parts of the world, improvement in rural infrastructure has been a major factor in providing farmer incentives for investing in improved agricultural technologies, for stimulating growth in off-farm employment opportunities, and encouraging nonfarm growth linkages. Evidence of these effects is most clear-cut in Asia, where there is a longer history of improvement in rural infrastructure (Hazell and Röell 1983; Ahmed and Hossain 1990).

Indirect benefits of improved infrastructure include better access to and use of social- and consumer-oriented services that help improve standards of living. In addition to improved health and education, improvement in rural physical infrastructure components, such as access to roads and markets, affects diets in a variety of ways. It opens up many new income-earning options for farm families; it may lower consumer prices and increase the variety of foods consumed by improving access to markets; and it often alters dietary preferences and eases women's work burdens by improving food-processing opportunities. More explicit work is needed on the effects of rural infrastructure development in Zambia.

By all indications, spread of improved agricultural technologies in Zambia would be facilitated with investment in rural infrastructure through improved access to input and output markets, better functioning of labor markets, and better access to agricultural services. In addition, it is also likely to improve the acceptance of new maize varieties as part of the diet through the expansion of local processing facilities such as hammer mills, which make it easier to process hybrid maize. The home premilling process that is used for local maize is unsuitable for hybrids.

Policy Environment for Hybrid Maize Adoption

Price Policies Favor Maize over Other Crops

At independence in 1964, Zambia inherited an agricultural price policy framework that was primarily geared toward commercial production of maize on the large-scale estate farms that provided maize to urban mine workers at subsidized prices in order to ensure an elastic supply of workers for the mines. Marketing of maize from producers to consumers was highly regulated and carried out by parastatals. Producer prices were fixed annually on the basis of numerous criteria, including cost of production and fair return to producers.[4]

In the postindependence period, this basic price policy framework has remained intact. However, a major additional objective was added in the early 1970s: producers in the traditional sector were to be subsidized at the cost of the large-scale estate sector in order to reduce reliance on the estates for the marketed supply of maize. This was achieved through a panterritorial pricing policy that, by establishing a uniform producer price in all parts of the country, subsidized farmers in remote rural areas and taxed the large-scale commercial enterprises established near the major town, road, and rail networks.

The price policy for agricultural products favors maize over other crops. This is reflected in the guaranteed producer prices paid over the past 15 years for maize relative to other crops. Figures available indicate that producer prices for maize increased 1,100 percent between 1975 and 1986, compared with 849 percent for soybeans, 773 percent for groundnuts, and 713 percent for sorghum. Increases for tobacco, wheat, sunflower, and cotton—other important commercial crops—were lower (Jansen 1986). Since 1986, the emphasis on maize prices has increased even further.

Promotion of Hybrid Maize as a Cash Crop

Consistent with the factors that were driving the emphasis on maize production was the focus on marketed production. Until recently, even production statistics interchangeably used the concepts of increase in production and marketed production. The technology package promoted for maize also matched this policy with the

[4]In the ex post facto analysis, however, these prices remained between the import parity (high) and export parity (low) prices in the years for which this information was examined (Kumar 1987b).

linked hybrid seed-fertilizer-credit package made available primarily to the emergent farmers in the smallholder sector.[5]

There were other characteristics inherent in the management of the production policy that contributed to production of hybrid maize as a cash crop. One of these was the unpredictability of when payment would be received for the maize harvest sold to the parastatal. Liquidity and management problems often led to a wait of several months before farmers got paid. Only the larger, more economically secure farmers could withstand this delay, because it meant that sufficient food stocks had to be retained to tide them over the wait.

Physical characteristics of the hybrid maize grain also fit in with the cash crop role. The hybrid maize varieties that have commonly been available belong to the soft (dent) grain type. They are difficult to process in the manner preferred traditionally, that is, wet milled—milled after being soaked, pounded, and sifted to remove the pericarp. This partially processed grain is then ground in the local hammer mill or, if none exists, at home. The refined meal is preferred for taste, storage, and cooking qualities. At the village level, the soft grain varieties are taken to the hammer mill to be ground into whole, unrefined flour, but this form is less preferred. The consumer subsidies for maize in Zambia have usually made it much more attractive to sell hybrid maize and buy back the refined form of subsidized maize meal if necessary.

Price Policy Environment Favors Sale versus Storage

Past maize pricing and marketing policies that have discouraged rural storage in favor of sale after harvest are also likely to have encouraged production of hybrid maize, at least in the short run. In the long run, lack of improvements in rural storage and increasing problems with parastatal handling of the marketed maize may have contributed to a plateau or even reduction in hybrid use, as is indicated by CIMMYT and farm-level statistics reported earlier (CIMMYT 1987; 1990).

One defect of the maize pricing policies has been the absence of a seasonal price increase for maize. The main contributor to this effect has been the large consumer price subsidy for maize meal. To the extent that this subsidy is being eliminated, the incentive for farm storage will improve. As a consequence of the lack of a seasonal price increase, virtually all maize marketings have been completed in the postharvest period when the guaranteed producer price can be obtained by selling to the grain marketing parastatals. Hybrid maize constitutes the main component of marketed maize production, while local maize is mostly stored for home consumption. Purchases, if required, have generally been of the preferred refined commercial maize meal product (breakfast meal) which, until the mid-1980s, actually had a higher subsidy than the coarser maize meal product (roller meal). Rural areas where these products are readily available have a flat seasonal producer price for maize, compared with a 17 percent seasonal increase in the price of groundnuts, a 23 percent increase in the price of beans, and a 14 percent increase in the price of sorghum between the postharvest months of June-July and November-December of 1981 in plateau areas of Chipata District (Kumar 1984).

[5]"Emergent farmers" is a classification of farm size used in Zambia to denote farmers in the traditional sector farming 10-20 hectares of land, whereas the majority of farmers cultivate less than 10 hectares. Therefore, these are the larger farmers and are likely to plant more hectares to commercial crops.

The extent to which hybrid maize has fit into the farming system of the smallholder Zambian farmer primarily as a cash crop may also have contributed to its failure to achieve its yield potential and, consequently, its acceptance. Since farmers' first priority is to ensure food security, they protect that by preferentially allocating area to local maize. This is indicated by the amount of area allocated to local maize production, which remains much the same on a per capita basis across farm size and level of hybrid maize adoption (as seen later). Farmers' priorities are also reflected in their planting of local maize at the onset of rains and hybrid maize later. As a result, the planting of hybrid maize is often delayed past its last recommended date, which is in mid-December (Harvey 1973, 20). This late planting of hybrid maize appears to be an important constraint in achieving its yield potential.

Input Subsidies

Subsidizing of both improved seed and fertilizer has been a steady feature of Zambian agricultural policy. However, there has been little careful analysis of the impact of these policies on agricultural productivity and input use patterns. To a large extent, political economy has dictated these policies, especially the panterritorial pricing policy for both inputs and outputs. Despite progress in structural adjustment, available information indicates that these subsidies have been hard to eliminate (Graham 1994, Ch. 6). As a consequence, the production of inputs locally also has to be subsidized and is likely to be hampered. For example, ZAMSEED has found it difficult to maintain a supply of seed from commercial seed producers, and thus to meet demand, especially from widely dispersed smallholders. Some efforts have been made, beginning in the late 1980s, to price locally produced fertilizer (primarily urea) at import parity levels, and production levels for that are reported to have improved as a consequence.

Access to Improved Technologies by Women

By the late 1980s, Zambian policymakers were beginning to recognize the importance of integrating women into sectoral development policies—to identify women farmers as a target group in agricultural sector strategies. Evidence was growing that women's role in agriculture was significant and that previous public sector programs had failed to reach them. Studies have shown that women farmers are less likely to receive agricultural credit, and when they do, the amounts are significantly lower than those for men (J. T. Milimo 1989). Women are poorly represented in agricultural extension and training programs (Eklund 1985; Chenoweth 1987; Bliven 1991), and they are also likely to face obstacles to stable land tenure not encountered by men (J. T. Milimo 1989).

However, improving women's access to improved technologies and resources requires more than political posturing and pronouncements. There is a wide gap between so-called policy statements and effective action (Keller and Mbewe 1988; Keller 1990). The problems are compounded by cultural practices that constrain women's rights and access to resources. Some of the major actions required include an improved awareness for both men and women at all levels—farmers, service providers in agricultural and other institutions, and policymakers—of the need for providing production opportunities and of the costs of inaction.

3

ANALYTICAL APPROACH AND METHODOLOGY

Nutrition Situation in Zambia

Protein-calorie malnutrition is a widespread and serious public health problem in Zambia. Zambia is not one of the most severely affected countries in Africa, but levels of protein-calorie malnutrition are above average (OAU/UNICEF 1992). A national survey in 1990 found 25 percent of children between the ages of 6 and 60 months to be undernourished (Cogill and Zaza 1990).[6] Malnutrition occurs more often in areas where infrastructure is poor, especially provinces off the line of rail and in urban squatter settlements. Eastern Province, where this research was carried out, has some of the best agricultural areas in Zambia, but it is an outlying province and therefore levels of protein-calorie malnutrition tend to be higher there (Ekberg and Mwale 1988).

There is also evidence of varying degrees of Vitamin A, iron, and iodine deficiencies in different parts of Zambia. Vitamin A deficiency occurs primarily in the northern areas, with sporadic cases in other parts of the country. Anemia, on the other hand, is a serious public health problem throughout the country. In 1970/71, it was present in about 70 percent of children under five years of age, 45 percent of men, 17 percent of all women, and 22 percent of pregnant and lactating women. Iron deficiency is only part of the etiology of anemia, with parasitic infections such as malaria, hookworm, and bilharzia being major causes (UNDP/FAO 1974). Goiter, resulting from primary or secondary iodine deficiency, affects people living primarily in the western and northern regions, where soils are poorer and heavily leached due to high rainfall and soil erosion, and where people rely heavily on cassava in the diet (OAU/UNICEF 1992).[7]

The nutrition of rural populations is inextricably linked with agriculture as the central source of food and livelihoods. Even though there have been high rates of rural outmigration in many parts of Zambia, remittances are, in general, an insufficient source of support for rural households with migrant members. Also, off-farm income sources such as wage employment or self-employment are extremely limited in areas outside the line of rail, where agricultural commercialization is not widespread. A number of area, household, and intrahousehold characteristics of agricul-

[6]Below two standard deviations from median weight-for-age of accepted international reference standards (U.S. National Center for Health Statistics [NCHS], as adopted by the World Health Organisation).

[7]High levels of cassava consumption have been noted to be goitrogenic, especially when the cassava is not adequately processed to remove the toxic compounds present in most varieties grown in Africa.

tural production influence levels of nutrition. Area factors include the natural resource base and agro-ecological characteristics, agricultural technology, cropping patterns, and the extent of commercialization of agriculture; household factors include farm size, productivity, off-farm income, fluctuations in income, education, and access to food; and intrahousehold factors include women's resource access and work patterns. These and other characteristics of agriculture affect the supply of foods and their prices and the effective demand for food and other services. Together they are among the major determinants of nutrition of population groups.

Role of Technological Change in Agriculture in Nutrition

Since the early days of the Green Revolution in the 1970s, there has been an ongoing debate about the effects on human welfare of technological change in agriculture. Generally, arguments have taken two opposing views. The proponents of each could be classed as the optimists and the sceptics. The optimistic view is that labor-intensive technological change in agriculture improves land and labor productivity, raises employment and incomes of the poorest households, and leads to large incremental improvement in aggregate food production and, hence, in food prices and affordability (Mellor 1966; Pinstrup-Andersen and Jaramillo 1991). In addition to the direct effects expected of these technologies, which are essentially embodied in better seed and fertilizer use, they generate rapid agricultural growth with linkage effects that stimulate rural investment in the off-farm sector (Hazell and Röell 1983). These linkage effects are expected to be especially favorable for the distribution of welfare benefits, particularly improvements in food security and nutrition, to the neediest groups in the population, including the landless (Ahmed and Hossain 1990; Kumar 1992).

On the other hand, the sceptics point to potential problems such as excessive concentration of wealth, unsustainability, environmental problems with improper use of inputs, loss of plant genetic diversity in the low-income countries, and exploitation by seed-producing multinationals (Brown 1970; Messer and Heywood 1988). The works of authors such as Lipton and Longhurst (1989) and Hart (1989) have been useful in putting the potential of these technologies in perspective and in pointing out that the results are not always as favorable as expected. Others have been concerned about the effects of localized improvements in the agricultural sector on the growth of poverty in areas where such improvements have not occurred (Pradhan 1993).

In addition to the issues of the level and distribution of household welfare, the intrahousehold dimension also entered into the debate during the 1980s. This was stimulated primarily by work in Africa, and was associated with efforts to bring new agricultural technologies to farming populations. Work done by several authors showed that although women generally had distinct responsibilities in agricultural production decisions, they were seldom able to obtain access to improved agricultural inputs.[8] This limited access by women was observed to be a factor in the limited success of these programs in raising agricultural productivity (Dey 1992). Other side effects of adoption of improved agricultural technologies by smallholder farmers that have been cited in other studies include a reduction in the share of household income

[8]See Kumar 1987a for a review of this work.

received by women and an increase in their share of household labor, often including women's labor devoted to agriculture. These intrahousehold dynamics have generally been viewed as a negative factor in producing improvements in child nutrition, since both a reduction in share of household income earned by women (Garcia and Pinstrup-Andersen 1987) and an increase in their workload (Kumar 1978; McGuire and Popkin 1989) decreases the quality of child care.

Recent reports that have analyzed the effects of household adoption of improved agricultural technologies have observed that in many cases, technological change and commercialization of agriculture are virtually synonymous (von Braun and Kennedy 1994). There is, however, wide diversity in the types of effects observed. A number of studies have documented this diversity in household and intrahousehold changes with technological change or commercialization in smallholder agriculture. Overall, household diets improved in terms of dietary caloric availability and intake, and this led to some improvement in child nutrition. However, the magnitude of the improvement was often small; in Kenya, for example, a doubling of household income led to a 7 percent improvement in child nutritional status.[9] Similar improvements in household income produced somewhat better nutritional gains in Malawi and Rwanda (Kennedy 1993).

Welfare Effects of Technological Change and Commercialization in Agriculture in Zambia

Few detailed analyses have considered the effects on nutrition and health of agricultural change in Zambia. Useful insights have, however, been obtained from studies associated with development programs, such as the Integrated Rural Development Program (IRDP), in different parts of the country. In cross-section comparisons, households with a higher degree of commercialization of crop production were generally found to have a higher incidence of child malnutrition than subsistence producers (FAO 1984; IRDP 1986). Anthropological research in one area suggests that there was a reduction in cropping and dietary diversity, especially in ingredients used in relishes or sauces served with the staple food, and a greater reliance on basic staples. In addition to a reduction in dietary diversity, an increase in the workload of women was also found to be a factor in the lower levels of child nutritional status in areas where agricultural development programs were being promoted (Keller and Mbewe 1988). In the present report, these and other factors associated with advancements in agriculture will be analyzed in detail.

Analytical Approach and Linkages

Technological change in agriculture has long been accepted as a necessary condition for accelerating growth in food production in Sub-Saharan African countries. The decline in per capita food production and availability in these countries over the past two decades bears testimony to the pressing need for addressing this problem with speed and clarity.

[9] Z-score for weight-for-height.

Technological change in agriculture to promote increasing yields of food crops is being emphasized for its expected effects on both supply and demand for food. Though the precise factors underlying adoption of new technology may be relatively complicated to analyze, tracing the distributional and welfare consequences of adoption is even more problematic. Adopters are more likely to experience income benefits at the household level, compared with nonadopters. However, translation of additional income into consumption and nutritional benefits is mediated not only by the profitability of hybrid maize production, but also by a wide range of resource allocation decisions. In addition, even at the local level, the effects of adoption may be linked to secondary income and employment generation that will benefit nonadopter households.

To trace the effects of hybrid maize production, the report looks at area, household, and intrahousehold conditions. It is, however, beyond the scope of this work to consider urban and regional benefits or disincentives that could be derived from the increase in marketed surplus of foodgrains in food-deficit areas outside the local area of adoption.

The basic analytical approach in this report is similar to other IFPRI studies on the effects of commercialization and technological change on household food security and nutrition, but with greater emphasis on intrahousehold dynamics. Adoption of improved technologies is expected to influence household-level characteristics such as disposable income and consumption expenditures that influence food consumption and nutritional adequacy. At the intrahousehold level, changes in income source, control of income, and women's workloads can influence the income and other resources that determine income allocation for food consumption, dietary adequacy, and levels of child nutrition among households but also among household members. These effects are predicted in both the commonly used neoclassical and bargaining-type models (Senauer, Garcia, and Jacinto 1988). In addition to the household and intrahousehold effects on resource access and allocation, technological change can also influence food demand and availability at the local level, affecting those who are not hybrid maize adopters as well as those who do adopt. For example, crop diversity, demand for wage labor, and demand for other local goods and services may all be affected.

Adoption of Hybrid Maize Cultivation Technology

Farmers in Africa face different and probably greater constraints to adopting improved agricultural technologies than farmers in Asia. These differences stem from three major conditions in Africa: low population densities, low average productivity of the resource base, and seasonal labor bottlenecks. All of these factors make capital accumulation and adoption of technological change more difficult (Delgado and Ranade 1987). These problems are compounded by poor infrastructure development, which increases riskiness of production and reduces access to local off-farm income sources that could assist in capital accumulation to sustain technological progress in agriculture.

For the individual farmer, adoption of improved agricultural technologies involves a complex set of considerations. Three aspects of the adoption process that are discussed in the literature are (1) risk and production uncertainty, (2) profitability and price incentives, and (3) the technological package and components selected for adoption and intensity of use. According to CIMMYT (1990), up to 40 percent of maize area in Sub-Saharan Africa faces occasional drought and production uncertainty. Farmer strategies are, therefore, geared to reducing risk to ensure at least enough production to meet minimum household needs. The adoption process itself is a reflection of that: those who do adopt have a better capacity to deal with risk and uncertainty.

Characteristics of adoption of hybrid maize reflect underlying conditions of risk-coping behavior and infrastructure constraints. For example, adoption is associated with increased farm size and with capital accumulation, but at the same time adequate area is still assigned to food crops to meet minimum household needs. Two other technologies are nearly always associated with hybrid maize adoption in Zambia and other countries in the region: application of a basal or top dressing of fertilizer (or both) and use of mechanical traction. According to World Bank analysis, the productivity of this technology package is often constrained by the unavailability of inputs when needed, and especially by a seasonal labor constraint that is accentuated on the large farms. The efficiency of this practice of households with the ability to expand area under cultivation in effect substituting land (with improved technologies) for labor in a "high input-low output system" has been questioned (World Bank 1992, 32).

Characteristics of adoption, such as which components of the package are accepted at any point in time, even though they may have a sequential component, are jointly determined by household and area-level factors. These characteristics include the decision to use a particular input—hybrid seed, fertilizer (plow cultivation), or pest control—as well as the intensity of use and timing and manner of application. Studies of the adoption of HYVs of maize in Zambia and other countries in the region indicate that it is jointly a function of adoption of planting technologies—mechanical traction (by oxen or tractor) and basal fertilizer (Jha and Hojjati 1993; Rauniyar and Goode 1992; Birch-Thomsen 1990). Less is known about the level of use of inputs, and use intensity is mostly a function of the ability of households to gain access to the limited supplies of subsidized inputs available.

Use of oxen or other mechanical traction for land cultivation has widely been associated with increased adoption of improved germ plasm technologies in Africa. There are several likely reasons for that, including the ability to spread out labor input (Delgado and McIntire 1982) and the ability to farm a larger parcel of land, which households desire because they wish to continue to grow local varieties for their own consumption. Very often, new seed varieties are not compatible with the existing storage and processing facilities that are available or local food tastes and are then treated as a cash crop. This has been widely observed in adoption of hybrid maize in Zambia, where in addition to the local storage and processing constraints, maize pricing and marketing policies did not encourage on-farm storage of surplus maize production (Kumar 1987b). These factors have led farmers to keep their original land under local maize varieties and to plant incremental area to cash crops like hybrid maize. As local maize milling facilities improve, farmers become more willing to keep hybrid grain for home consumption, but only enough to last until the start of the rainy season. The existing storage facilities do not enable the softer hybrid grain to withstand pest attacks with the onset of the rains. To encourage improvements in on-farm storage, there has to be a shift in pricing and marketing policies as well.

Fertilizer use, encouraged by heavy price subsidies, has been growing in Zambia. An IFPRI survey in Chipata District in 1981/82 showed that fertilizer use was limited primarily to hybrid maize and cotton production. A repeat survey in Eastern Province in 1986 found fertilizer use much more widespread, including its use on local maize (Jha, Hojjati, and Vosti 1991). There has, however, been a limited yield response to this additional fertilizer use (World Bank 1992). This can be attributed partly to poor timing and quality of fertilizer application, insufficient weeding, and declining soil quality due to continuous cultivation of maize. The use of fertilizer on local maize, which is a recent phenomenon, is largely a response to declining soil fertility.[10]

Insufficient labor for crop management activities such as land preparation, planting, and weeding is widely acknowledged to be an important constraint in obtaining the potential benefits from use of improved technologies. Factors that could accentuate a labor constraint, particularly related to hybrid maize, are (1) area expansion associated with hybrid maize production increases total household labor demand, (2) use of fertilizers increases the need for timely and adequate weeding, and (3) intrahousehold control of the crop by men could influence the extent of labor input.

The central focus for this analysis will therefore be on adoption of the improved maize seed and fertilizer technology, with labor use and oxen cultivation as additional factors that determine overall farm and hybrid maize productivity.

At the household level, the effects of adoption consist primarily of (1) changes in household income and consumption expenditure, (2) changes in who controls income within the household and the effect on women's income, and (3) changes in labor allocation patterns. These effects can, in turn, influence calorie requirements and adequacy and the ability of women and other household members to care for children. All of these primary consequences of adoption are therefore expected to influence food consumption and child nutrition.

Consequences for Household Income and Expenditure

Jha and Hojjati (1993) find that income, especially from nonfarm sources initially, is likely to facilitate the ability to grow hybrid maize. Once a household has successfully adopted, the income advantage over local maize is usually demonstrated. The extent to which hybrid maize adoption improves household income and consumption expenditure will of course depend on the productivity and profitability of the improved variety on a particular farm. As indicated earlier, the amount of labor available and the timeliness with which procedures are undertaken is even more important than fertilizer application in the improvement of agricultural productivity with adoption of high-yielding varieties (World Bank 1992). This analysis takes this issue further by distinguishing the income effect of hybrid maize adoption from the effect of increasing area under hybrid maize.

Consequences for Women's Income and Decisionmaking

There is, by now, a voluminous literature on the effects of modernization of agriculture on the economic role and welfare of women. Two main types of effects can be related to nutrition outcomes, especially for children: the effects on intrahousehold income and the effects on time allocation of women. It is well accepted by now that men and women are likely to allocate income differently, and that the pooled income of different household members is a poor predictor of nutrition outcomes of individual members (Haddad 1992). Similarly, women's work in in-

[10]Declining soil fertility is attributed to villagization programs introduced during the 1970s that aimed to bring dispersed homesteads together into clearly identifiable villages, which contributed to a shift from extensive to intensive and continuous cultivation.

come-generating activities may conflict with their activities in providing food for the household and in child rearing, especially feeding and caring activities that contribute to improvement in children's nutritional status (Leslie 1989).

In rural Zambia, women's production of agricultural products and access to improved production technologies will largely influence their income and time allocation. It is expected that women in male-headed households, who have relatively low access to improved technologies, will have access to a smaller share of household income, and that demand on women's time for both income generation and production of household consumption goods and other Z-goods[11] will increase with an increase in household income.

In households headed by women, a low level of improved technology use would mean that women, in general, have low access, and that this would be reflected in lower income. It is hypothesized that reduced women's income will be detrimental to household food consumption and child nutrition, but that reducing demand for women's labor in agricultural production will benefit household food consumption and child nutrition by improving their ability to allocate sufficient time to performing these services.

Consequences for Household Labor Allocation

Hybrid maize adoption is associated with cultivation of a larger area so that there is no decline in the area sown in local maize. This was found to be true in surveys by the International Food Policy Research Institute in Eastern Province in 1981-82, and again in 1986. In neighboring Malawi, where maize is also the staple food, nearly all farmers that adopt hybrids also plant local maize for their own consumption (Smale 1991). In parts of Zambia—Central Province, for example—new varieties were widely adopted by the late 1970s, but the majority of farmers were still planting finger millet, the preferred staple in that area (CIMMYT/GRZ 1978). Because of this and other characteristics associated with adoption of hybrid maize, together with underlying seasonal labor constraints, household members are likely to face difficult labor allocation choices.

Hybrid maize production requires a higher labor input per hectare than local maize to reach potential yields. However, most field observations suggest that actual labor input is lower on hybrid maize than on local maize (Jha and Hojjati 1993; ARPT/Eastern Province 1988). This is consistent with the substitution of inputs for labor suggested earlier and the difficulty of obtaining hired labor.

The extent to which household labor input, and, in particular, intrahousehold labor allocation is influenced by hybrid maize adoption determines its consumption effects. The availability and use of nonhousehold labor is a factor in this labor response, but also intrahousehold dynamics of labor supply and demand. If additional household labor is directed to hybrid maize, it could have two possible effects. First, it could increase the demand for calories simply by virtue of the higher workload of members, and, second, if this increase is accompanied by an increase in women's labor, then

[11]According to neoclassical economic theory, the composite of household utility is made up of Z-goods, which combine purchased items with time of household members into final products that enter into their utility function (Becker 1965).

there could be adverse household food consumption and child nutrition implications because women's time for those activities might be curtailed or less effective.

When wage labor use in agriculture is widespread, as in Asian countries, and competitive nonagricultural opportunities exist, household labor input in agriculture is a decreasing function of total area cultivated by the household, especially the women's labor component. However, in areas where population density is low, as in most of Zambia, farmers are less likely to hire wage labor. Instead, household labor in agriculture is expected to increase with farm size and to be positively affected by increasing household size and the number of working-age members. The extent to which this increase in labor input occurs with adoption of hybrid maize and increasing farm size will depend on the opportunity cost of alternative uses of time by each household member. This could differ for males and females if males are predominantly engaged in market-oriented nonagricultural work that is easily substitutable for agriculture, whereas women are primarily engaged in household maintenance activities for which increased income from agriculture may not easily substitute.

The household labor response for agricultural production is expected to be determined simultaneously by exogenous factors that also influence the household income effect. Both of these are expected to influence the supply (through the substitution effect) of and demand (through the income effect) for household labor in nonmarket activities, including leisure. This nonmarket labor includes household maintenance activities such as food processing, cooking, collection of fuel and water, and house repairs. These activities are hypothesized to be important in determining the beneficial effects of agricultural technology adoption on household food consumption and child nutrition. These associations will be examined in the analysis.

Effects on Household Food Consumption

In order to trace the effects of hybrid maize adoption on facets of household food consumption, the approach adopted is to first trace the consequences of adoption on the determinants of consumption, and then, from the strength of the different causal factors, to draw implications for consumption and nutrition status. This approach is preferable to using adoption per se as an explanatory factor, since the technology itself creates a potential for improving the income and food consumption situation but is translated into inter- and intrahousehold effects via a complex set of social and economic conditions, which may be amenable to policy intervention.

In explaining differences in dietary intake, the main predictors that are influenced by hybrid maize adoption are income- and time-related variables. Changes in availability of foods, usually reflected by prices in local markets, are also important. However, because of producer and consumer price controls in effect, a large part of food transactions take place informally, and prices are hard to measure. Household income can be influenced by adoption of agricultural technology through a combination of direct effects and by indirect area-level effects on employment and food availability. In addition to household-level income effects, intrahousehold distribution of income is also tested for its impact on household diets. Time allocation, especially by women in consumption-related activities, is also expected to be a factor in consumption effects of increased income. The allocation of time is hypothesized to be influenced by improved technology adoption through a combination of labor allocation decisions and income effects.

Dietary characteristics examined are per capita calorie intake, calorie intake at the household level in relation to household composition and workload, per capita protein intake, and a diet diversity indicator for overall diets, as well as home-produced and purchased components. The protein and diet diversity measures are included to give an indication of improvement in diet quality, which is often more important for child nutrition than improvement in dietary calories alone.

Effects on Child Nutrition

The direct determinants of good child nutrition are adequate diet and child care and absence of disease. However, there are several problems with tracing the effects of hybrid maize adoption on child nutrition. First, the direct determinants of child nutrition are the result of a complex mix of area-, household-, and intrahousehold-level effects of agricultural change. Second, many child nutrition measures, for example, weight-for-age and height-for-age, are the result of cumulative effects on the child that begin even before its birth. This often makes it difficult to account for a large part of the variation in these measures. Third, it is difficult to disentangle the simultaneity between the various factors that contribute to nutritional status. For example, time allocation of women is a contributory factor in food intake and child health, both of which contribute to a child's nutritional status. However, in addition to influencing these two factors, there may be an additional effect of women's time allocation not captured by these variables, that is, the quality of care given. Similarly, while women's control of income could influence the allocation of more household resources directed to food, it could also influence allocation of food within the household so that child nutrition is affected.

In order to resolve these problems, particularly the problem caused by the endogeneity of causal factors such as household food intake and child morbidity, an instrumental variables approach is used. Estimated values of household dietary parameters and predictors of child morbidity are used—water, sanitation, and access to health services. In addition to these and women's time allocation, other variables are included that could influence intrahousehold resource allocation, such as who heads the household and who controls income.

Theory and Analytical Model

The main issues of interest in the present analysis are the effects of agricultural production, in particular adoption of hybrid maize cultivation, on household food consumption and child nutrition. According to current analytical practice, these outcomes can be directly modeled as part of the household's utility function (Behrman and Deolalikar 1988). The basic model for an agricultural household must deal with the problem that household decisions affecting production and consumption are likely to be made simultaneously, with each affecting the other. It is, however, possible to model these recursively, that is, with production decisions in one period affecting consumption outcomes in the second period, which could then affect production decisions and outcomes in the third period, and so on. In the present data set, the information was available for only one production cycle (one calendar year), therefore the problems of simultaneity in making these associations need to be resolved.

Since food consumption, nutrition, and health outcomes are part of the households' utility function, they are given by choices made in the allocation of both income and time to these activities directly, and are subject to a combination of budgetary and time constraints. In the household model, these are all endogenous variables, but a set of reduced-form demand functions can be specified, in which both the production- and consumption-related outcomes are left-hand-side variables and are given by variables that are exogenous to the household.

At the base of the household model is the concept of full income in which both income flows and time contribute. As initially proposed by Becker (1965) and developed further in the human capital investment literature,[12] households derive utility from Z-goods—or final products that are primarily a combination of commodities and time of household members. These Z-goods include, for example, health, nutrition, and food consumption outcomes, in addition to others such as social and educational outcomes. Tastes, as well as individual and household endowments, can influence the outcomes of this process. Thus,

$$Z_i = Z(x_i, t_i, e_{ij}), \tag{1}$$

where x_i is a vector of market goods, t_i is a vector of time used in producing Z_i, and e_{ij} is a matrix of individual and household endowments.

It is these Z-goods, the health and nutrition of its members, that contribute to a household's utility. Therefore, maize in the store does not provide much consumption utility, but after it has been processed, cooked, and served, its utility goes up. Time allocation data from rural households as well as field observations show us that much of the time spent by rural households on non-income-earning activities is in the production of such Z-goods. Household production functions for income contribute to both the disposable income and allocation of time.

The income-generation function reflects a maximizing choice given the sum of individual and labor market characteristics. Thus, while disposable income (Y) helps in the acquisition of market goods, it is also a reflection of time allocation decisions of household members between alternative sources of income. Simply put,

$$Y = E_{xi} + S = L_i w_i + E, \tag{2}$$

where

E_{xi} = total consumption expenditure,
S = savings,
L_i = labor allocation to alternative income generation activities,
w_i = the wage rate in the i^{th} income-earning activity, and
E = nonlabor income.

The net income effect of hybrid maize adoption will be conditional on the improved returns to labor in agriculture and shifts in labor allocation between different sectors.

Taking the two main sectors in which labor can be allocated to income-earning activities to be farm and off-farm, w_1 the shadow wage rate in agriculture, and w_2 the wage rate in off-farm employment, then, first, w_1 will be a function of profits, that is, derived from a combination of farm production technology and prices of inputs and outputs. In addition, when farm production is primarily for own consumption and

[12]See, for example, the discussion of household production of health and nutrition by Behrman and Deolalikar (1988).

agriculture labor markets are virtually nonexistent, as was the case in Eastern Province, then w_1 will depend on *both* the production technology and household preferences (Strauss 1986).

Second, L_1 and L_2 are the labor of household members allocated to farm and off-farm work, respectively, and each is given by w_1 and w_2 as well as by prices of inputs and outputs and the utility function. It can be shown that for farm households with different utilities for farm and nonfarm work, structural equations for labor supply to the farm and off-farm sectors can be derived with

$$L_i = L_i(T, q, w_2, Z), \tag{3}$$

where

T = the farm production technology,
q = a vector of input and output prices that influence the returns to farm labor,
w_2 = the off-farm wage rate, and
Z = a vector of Z-goods demanded by the household (Lopez 1986).

The food consumption and nutrition outcomes of hybrid maize adoption will be the result of the effective demand for Z-goods, given the net income and time allocation effects and given that

$$Z_i = Z(x_i, t_i, e_{ij}) = \mathrm{f}(Y). \tag{4}$$

Thus, while disposable income contributes to the demand for purchased commodities such as foods, it also affects the demand for t_i that goes into the production of Z_i.

Based on the outline presented above, the analytical model consists of equations that first predict the income and time allocation effects of hybrid maize adoption, and then use these predicted values in explaining food consumption and nutritional outcomes. The model consists of the following recursively estimated equations:

1. A predicting equation for the adoption of hybrid maize as the main indicator for the level of farm production technology used. This is estimated using a two-step or Heckman approach, which first estimates the probability of hybrid maize adoption and then, conditional on adoption, estimates equation (6) by ordinary least squares, correcting for truncation bias:

$$HM = \mathrm{f}(E_1), \tag{5}$$

and

$$HMA = \mathrm{f}(HM^*, E_2), \tag{6}$$

where

HM = observed hybrid maize adoption,
HM^* = probability of hybrid maize adoption,
HMA = area under hybrid maize conditional on adoption, and
E_1, E_2 = vectors of exogenous variables.

Examples of exogenous variables are household and area characteristics, fixed assets, and nonlabor income.

2. Since agricultural technology and the option of improvement in productivity will influence both labor allocation decisions and disposable income outcomes,

$$Y = f(HMA^*, E_3), \tag{7}$$

and

$$L1_i, L2_i = f(HMA^*, E_4), \tag{8}$$

where

HMA^* = predicted area under hybrid maize production,
E_3, E_4 = vectors of exogenous variables,
$L1_i$ = household farm labor by males and females estimated separately, and
$L2_i$ = household off-farm labor by males and females.

The allocation of household labor for farm and off-farm work is estimated separately for males and females living in the household. Predictors include farm technology adoption, human capital endowments of household members, an indicator of intrahousehold differences in preferences in farm and off-farm labor allocation, and exogenous variables. Since prices for both inputs and outputs were fixed by policy measures, variations in input use and marketed output are likely to be a function of other variables, such as being located in a well-functioning cooperative area and membership in it. Therefore, price variations per se are not likely to be a factor in farm productivity.

3. The next set of equations estimates the time spent on nonlabor activities such as those involved in consumption support activities, T_i. This will be the compensated effect of the shadow wage rate changes with adoption of improved farm technology, and will be through a combination of the well-known income and substitution effects:

$$T_i = f(Y^*, HM^*, HMA^*, E_5), \tag{9}$$

where

T_i = time spent in household maintenance activities by males and females,
Y^* = predicted value of household disposable income derived from equation (7),
E_5 = vector of exogenous variables.

The other terms are defined as before.

4. Food consumption is next estimated as a function of disposable income (Y), its intrahousehold control, time spent by household members in household maintenance activities (T_i), and exogenous variables:

$$C_j = f(Y^*, Fs, T_i^*, A, E_6), \tag{10}$$

where

C_j = household caloric, protein, and diet diversity measures,
Fs = an indicator of women's share of income,
T_i^* = predicted values for male and female time spent in household maintenance activities,

A = area-level factors that influence food prices and availability, and
E_6 = vector of exogenous variables.

5. Child nutritional status is estimated using the predictors of demand for food and health care, which are the main direct factors in child nutrition, time spent in household maintenance activities by males and females, indicators of the health environment and access to health services, as well as other child- and household-specific characteristics:

$$NS_{ik} = f(Y^*, Fs, T_i^*, H_i, C_i, E_7), \quad (11)$$

where

NS_{ik} = the nutritional indicator for the child in season k,
H_i = indicators of the health environment and access,
C_i = child characteristics such as age and sex, and
E_7 = vector of household variables.

A seasonal dimension is added with seasonal intercept variables and a random effects estimation model.

In the above system of equations, the vectors E_1 through E_7 are such that the equations are fully identified. Variable details and results will be presented later in the report.

Data Sources

Selection of Study Sites

Ten representative sites were chosen from Eastern Province including sites in all administrative districts. These locations had been originally selected by the World Bank-funded Eastern Province Agricultural Development Project (EPADP) to monitor their activities in the province. The branch was the local administrative unit in each of the selected sites. Each branch consisted of about 10 villages, with each village having an average of 25 households. Though sites were located in each of the districts, they were not chosen to be representative of each district; rather, collectively they represent the provincial rural population.

Selection of Households

Within each branch, four stratifying criteria were selected. These were (1) use or nonuse of hybrid maize seed, (2) use of oxen or hoe cultivation, (3) male- or female-headed household, and (4) contact farmer status.[13] A census of the total population in the sampled branches was carried out, which recorded information on each of the stratifying criteria. Households were grouped into all possible combinations of the stratifying criteria, and households were randomly drawn from each group, selecting the N^{th} household, where

[13]The training and visit (T&V) program, which was a central part of EPADP's activities, used contact farmers as a focal point for spreading the extension message.

$$N_i = \frac{B_i}{33}. \tag{12}$$

where B_i is the number of households in the branch and 33 is the number of households to be selected in each branch. This size of sample represented about 15 percent of the branch population—a total of 330 households.

Measurements

Frequency of Visits

Households were visited monthly beginning in December 1985 until December 1986 and interviewed to obtain information on the main questionnaire. Additional modules were incorporated for information not requested each month.

Types of Measurements

Measurements were based on interviews with selected household members for most items in the study. Actual measurements were made for some items, such as size of farmed area and output, and for anthropometric indicators of nutritional status of all household members. Area farmed and output were measured for the 1986 harvest year. Anthropometric measures (weight and height) were taken during four of the monthly rounds to capture seasonal variations in nutritional status.

Modules for Primary Focus in This Analysis

Labor Allocation. This information was obtained for each individual working during the previous month on an activity in a set of five different modules: agricultural work by plot, different postharvest activities, different livestock activities, nonfarming activities of a self-employed nature, and wage employment activities. With the exception of agricultural work, which was recorded in days worked, all other activities were recorded in a way that could be converted directly into hours of work. Since information was obtained according to the individual engaged in the activities, this was converted later into labor allocation by age, sex, or other categorization.

Food Consumption. This information was obtained by using a modified food frequency/expenditure recall for the past week. To do this, first a detailed list of all possible food items that could be obtained was compiled. In conducting the interview, the enumerator was instructed to interview the female who was primarily responsible for food preparation. They first went through the list and marked those items that were present in the household diet during the previous week. Then they obtained the number of days an item was consumed and the typical amount used each day, in a meal, and during the week, or, for items consumed in small amounts, the total time elapse for completing a given amount. Quantities were obtained through a combination of a set of standard units that were provided to the enumerators and a series of standardized local units. The approach was intended to be as flexible as possible to fit into the pattern of food acquisition employed by the household for each food item it consumed during the previous week. Additional information was obtained on the source of the item and, if purchased, the frequency, amount, and price or expenditure entailed. Recording the status of the food quantity, whether in edible portions or "as purchased," was also important in converting the quantities into nutrient consumption.

Often, food expenditure surveys record foods in the "as purchased" form, and if this entire quantity is treated as "edible," the consumption figures may be substantially inflated. Other information included in the food consumption module included attendance at meals and meals provided to guests and workers.

Intrahousehold Decisionmaking. This information was obtained in two modules, each of which was implemented once. The first was aimed at cash expenditures made in agricultural production, distribution of income from sale of produce to different household members, and their patterns of allocation of income received. This part of the survey was conducted in the postharvest month of September 1986. The second module was aimed at all food and nonfood cash expenditures and was carried out during December 1986.

An attempt was made to determine the involvement of household members in different parts of the decisionmaking process, as described by Acharya and Bennett (1981). For example, in the case of cash expenditures in agricultural production, the sequence of decisionmaking was represented by who suggested the expenditure be made, who arranged or negotiated for the item to be purchased, and who actually paid for it. For sale of produce, the sequence was who suggested the sale, who arranged or negotiated it, and how were the proceeds distributed within the household. For food and nonfood expenditures, the sequence was who suggested it, who paid, and who went to purchase the item. Dividing the decisionmaking process in this way provides a more realistic description of intrahousehold decisionmaking and reduces ambiguity and conflicting responses.

Health Status. Morbidity recall during the previous month was included in the main monthly questionnaire. Illnesses were identified either by commonly known names or by symptoms. The duration of the illness for each member who was reported ill during the month and the nature of treatment were also recorded.

Nutritional Status. Assessment of individual nutritional status was made by anthropometry four times during the year to capture seasonal variations. Weight and height (or length for children under two years) was recorded for all household members during visits in February, June, September, and November of 1986. These periods represented heavy work with severe food scarcity (February), early harvest (June), postharvest (September), and start of the next planting cycle (November). Age assessments and verification were made, based on a combination of hospital and birth records, local events calendars, and questioning the mothers of young children on the season or month of birth and years completed.

Involvement of Local Institutions in Study

The design and implementation of the study was done jointly by research staff from three divisions at IFPRI in cooperation with specialists from the Zambian Nutrition Commission, the Rural Development Studies Bureau of the University of Zambia, and the Eastern Province Agricultural Development Program of the Provincial Planning Unit. It was a truly interdisciplinary collaborative project, which was first presented to Zambian analysts and policymakers and was later edited for publication (Celis, Milimo, and Wanmali 1991). This report gives a fuller analysis of the nutritional and food consumption effects of hybrid maize adoption and discusses the implications in light of current policy reforms in Zambia.

4

AGRICULTURE IN EASTERN PROVINCE

Characteristics of Eastern Province

Eastern Province is one of the major agricultural regions of the country, consistently producing large grain surpluses required for the urban centers. It has, nevertheless, remained predominantly a rural province. It has the lowest percentage of urban population of any Zambian province—only an estimated 14 percent in 1990 (Table 3). This compares with an overall Zambian urban population of 49 percent, and is even lower than the relatively underdeveloped agricultural provinces of the north and west.

It has a low population density, about 10 persons per square kilometer, and the farming population is largely in the traditional sector, with farms averaging 2-3 hectares. In rural areas, agriculture provides nearly 90 percent of household income through production and employment. Most of the households rely on own production for the major part of their consumption, with the relatively deficit areas relying more on food purchases. It is also interesting to note that income sources are more diversified in the poorer agricultural areas (Honeybone and Marter 1979). This is also consistent with the changes in labor allocation patterns observed in this report; it suggests that rural areas in Zambia are in the initial stages of agricultural transformation, in which other income sources are sought to overcome the uncertain and low returns from agriculture. This diversification is different from that observed in the later stages of agricultural development, in which households invest surplus produced in agriculture in local nonagricultural enterprises and produce linkage effects in the growth process.

Table 3—Population distribution in urban and rural areas, by province

Province	1990[a]			Percent	
	Total	Rural	Urban	Rural	Urban
Central	720	411	309	57	43
Copperbelt	1,751	135	1,616	8	92
Eastern	882	760	122	86	14
Luapula	526	408	118	78	22
Lusaka	1,108	163	945	15	85
Northern	867	647	220	75	25
Northwestern	380	319	61	84	16
Southern	937	626	311	67	33
Western	574	479	95	83	17
Total	7,745	3,950	3,795	51	49

Source: P. D. Ncube, "The Zambian Food Strategy—Aspects of Production," in *Agricultural Baseline Data for Planning*, ed. P. D. Ncube (Lusaka: Zambia, National Commission for Development Planning and the University of Zambia, 1983).

[a]Projections for 1990 based on 1980 census.

The high degree of reliance on agriculture seen in the Eastern Province of Zambia is typical of rural areas in Africa where there is a combination of poor infrastructure development and relatively good agricultural potential. The poor infrastructure development generally precludes the rapid modernization of agriculture and growth of nonfarm employment and income in the area (Haggblade, Hazell, and Brown 1989). At the same time, the relatively good agricultural potential enables rural households to meet basic needs without seasonal migration, which in areas such as the Sahel are essential for survival of rural households (Reardon, Matlon, and Delgado 1988).

Ecology, Rainfall, and Climate

Eastern Province has some of the best agricultural lands in the country. It is mostly situated on the Eastern Plateau, which is characterized by moderate rainfall of 800-1,000 millimeters a year. Zambia is commonly divided into four agro-ecological zones (Figure 1). Of these, Zone 1 is the northernmost high-rainfall area, with an annual average of more than 1,200 millimeters. This zone occupies 46 percent of land area and is traditionally a cassava and finger millet producing area. Although it is ecologically regarded as unsuitable for maize growing, it has over recent years become an important maize-producing area due to favorable production incentives. Zone 2 consists of the western semi-arid plains and has a low rainfall (less than 800 millimeters); main crops are cassava, bulrush millet, and sorghum, as well as some maize. It has a large cattle population and is well suited for it. Zone 3, which consists of (a) the Central and Southern plateaus and (b) the Eastern Plateau, constitutes only 12 percent of the land, but it produces most of the agricultural surpluses, especially for maize. It has moderate rainfall and some of the best soils in the country. The main crop is maize, but smaller amounts of groundnuts, sunflower, cotton, soybeans, and tobacco are also grown. Most of the study sites are located in this zone. Zone 4 is composed of the Luangwa-Zambezi rift valleys, which have good soils and irrigation potential but are located away from population and infrastructure and have had little improvement in agriculture. Rainfall is low (less than 800 millimeters) and erratic. Consequently, these are generally considered food-deficit areas. Two of the 10 study sites are located in the Luangwa Valley in this zone.

The rainfall is unimodal, with the rainy season lasting from November to March and with 70 percent of rainfall occurring during the months of December through February. The temperature peaks just prior to the start of the rains, at a mean monthly temperature in October of about 27 degrees centigrade on the Eastern Plateau. The coolest month is in the middle of the dry season in June, when the mean monthly temperature on the Eastern Plateau is about 18 degrees centigrade.

Vegetation is predominantly moist savanna (long grass) with scattered woodland, with the valley areas characterized as dry savanna. Tsetse infestation is high in the Luangwa Valley (Zone 4) and cattle rearing is, thus, infeasible there. Efforts to curb its spread on the plateau are under way and have been largely successful. However, areas bordering Mozambique have had a recurrent problem with this infestation coming across the border.

Importance of Maize in Production and Consumption

Eastern Province is in one of the most fertile and productive agro-ecological zones in Zambia. It has an altitude of about 920 millimeters and an average rainfall of about 900 millimeters. The rest of the province is in the Luangwa Valley, of which nearly half takes the form of a rocky and uncultivable escarpment. Although the soils of the

Luangwa Valley are better than in other areas in the low rainfall zones, rainfall tends to be unpredictable, and flooding is common. The valley also has tsetse infestation, making it unsuitable for livestock. Thus it lacks draft power for crop cultivation.

The plateau areas of Eastern Province (Zone 3b) are among the main maize-growing regions of the country (Table 4). Although there is somewhat more crop diversity in the valleys (Zone 4), maize is still the main grain crop. Other grains also grown in the valley are sorghum, finger millet, and rice (bulrush millet is not grown to any significant degree in the Luangwa Valley). Cotton is an important cash crop.

Provincial grain consumption patterns largely mirror the production pattern of the agro-ecological zones, with maize being the staple in the plateau areas, and with a larger share of cassava and sorghum and millets in the diet in the high- and low-rainfall areas (Figure 1). The main producing provinces of the plateau areas are Lusaka, Copperbelt, Southern, and Eastern and these all have maize as the predominant staple. Cassava is the main staple (in weight terms) for Luapula and Western provinces, and it is an important second staple to sorghum and millets in the Northern and Northwestern provinces.

For the country as a whole, maize is by far the most important staple (Table 1). Even though large parts of the country lie in areas where it is not the main crop, it is grown and consumed in the provinces that tend to have more densely populated rural areas. Maize is also the main staple food in the urban areas, which comprise nearly half the population of the country. Altogether, maize is the staple for nearly 75 percent of the population. Table 1 also shows that cereals and cassava contribute from about 1,200 calories per day in Luapula to over 2,000 calories in Lusaka and Central provinces.

Agricultural Development Institutions and Programs

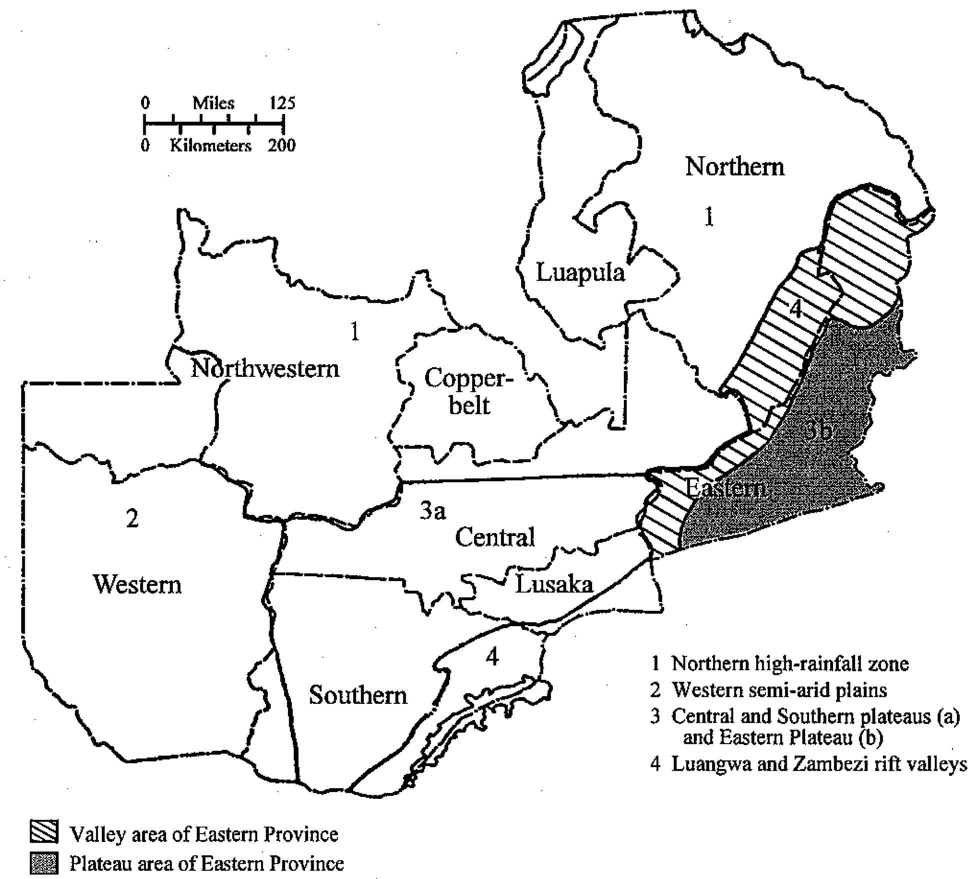
Overall, investment in agriculture has remained a relatively small share of public expenditures. In the first and second national development plans implemented between 1966-70 and 1972-76, the level of planned public-sector investment for agricul-

Table 4—Production of major crops by agro-ecological zones, Zambia, 1979-80

Crop	Unit	Zone 1	Zone 2	Zone 3a	Zone 3b	Zone 4	Total
				(thousands)			
Maize	90-kilogram bag	730.8	94.3	4,629.5	2,209.0	102.1	7,765.7
Sorghum	90-kilogram bag	186.0	24.0	21.4	...	39.2	270.6
Finger millet	90-kilogram bag	512.6	64.2	4.6	10.0	13.7	605.2
Bulrush millet	90-kilogram bag	...	63.9	...	...	20.0	83.9
Cassava	60-kilogram bag	2,937.8	881.4	24.8	4.2	10.7	3,858.9
Beans	90-kilogram bag	34.8	0.6	1.6	...	...	37.0
Soybeans	90-kilogram bag	4.3	...	12.6	...	...	16.9
Rice	80-kilogram bag	27.0	15.8	0.8	7.5	4.4	55.5
Wheat	90-kilogram bag	33.3	0.9	53.1	...	...	87.3
Groundnuts	80-kilogram bag	13.8	3.0	31.6	134.9	2.2	185.5
Sunflower	50-kilogram bag	13.3	1.5	291.7	53.1	18.2	377.8
Cotton	1 kilogram	139.0	40.0	20,997.0	3,908.0	4,696.0	29,780.0

Source: Zambia, *Food Strategy Study* (Lusaka: Ministry of Agriculture and Water Development, 1984).
Notes: Zone 1 is the northern high-rainfall zone.
Zone 2 is the western semi-arid plains.
Zone 3a consists of the Central and Southern plateaus; Zone 3b is the Eastern Plateau.
Zone 4 is the Luangwa and Zambezi rift valleys.

Figure 1—Map of Zambia's agro-ecological zones



Notes: These zones are adapted from the World Bank's classifications. The dashed lines indicate province borders; the solid lines are zones.

ture was only 12.2 and 11.3 percent of total public-sector investment, respectively. Between 1971 and 1978, the real value of total agricultural allocations was reduced by more than half. Another feature of expenditures on agriculture has been the prominent role played by subsidies, especially maize marketing subsidies to NAMBOARD, which accounted for more than 40 percent of all government allocations during the 1970s (World Bank 1981). Between 1978 and 1985, the real value of agricultural sector allocations continued to decline sharply, but since then they have shown an upward trend (World Bank 1992).

The main activities for agricultural development are undertaken either by the Ministry of Agriculture, which is responsible for agricultural research and extension, or the parastatal organizations that are responsible for delivering inputs—NAMBOARD in some provinces and the provincial cooperative unions in the rest. Other organizations feed their products through these, including those providing credit, seed, and fertilizers. Some commodities, for example, cotton and tobacco, have separate institutions that deal directly with all the farmer's needs for inputs for producing the crop and with its marketing.

Over the years there has been an evolution in thinking about mechanisms for promoting agriculture. Initially, the efforts were largely centered outside the traditional farming sector, and these included state farms in the immediate postindependence years, followed by "rural reconstruction centers," which were intended to be run by youths recruited from urban areas. In the early 1970s, areas with promising agricultural potential were targeted with the Intensive Development Zone (IDZ) programs, which aimed to deliver an integrated package of inputs and services to "emergent" farmers from the traditional sector. By the end of the 1970s, the IDZ concept was expanded into the IRDP, which was intended to expand coverage of agricultural development efforts to all rural areas. Other programs adopted during the 1980s include the Lima program, the Adaptive Research Planning Team (ARPT), and, on an experimental basis, the traning and visit (T&V) system. All these programs were in operation in Eastern Province during the present study.

Crops Planted in the Study Area

There is a fair amount of variation within the province in the importance of different crops in the farming system. Overall, 83 percent of land was devoted to maize production, with local maize at 60 percent and hybrid maize at 23 percent (Table 5). Maize production was found to be most important in the Chadiza and Katete sites, where it was more than 90 percent of total farmed area. In parts of Lundazi, the maize area was also nearly 90 percent of area. Maize area was lowest in Mambwe and Chama, the two valley sites, while secondary cereal crops (rice, finger millet, and sorghum) were highest. Even though the study sites in each district were not representative of the overall district characteristics, these differences are indicative of the nature of variations within the province.

Nearly twice as much of the local maize area was intercropped as in sole stands. As one would expect, more of the hybrid maize was in sole stands, but a sizable amount (about one-third) was intercropped. This represents a change from the early years of hybrid maize adoption, when it was grown almost exclusively in sole stands. This could be the result of recent emphasis on intercropping by the agricultural research and extension groups in Zambia to reduce the time required for weeding labor.

The valley sites are striking in that much smaller areas are farmed per household (Table 6). However, the total share of area devoted to cereals is very similar in the plateau (89 percent) and valley (83 percent) sites, with valley areas more likely to grow secondary cereals, such as rice, sorghum, and finger millet, while the plateau sites specialize almost exclusively in maize production. Hybrid maize, as mentioned earlier, is also virtually absent from the valley sites. Groundnuts, beans, and cowpeas covered only 10 percent of farmed area (they had additional area as intercrops in maize fields), while cotton and sunflower area was only 3 percent. For both of these groups of crops, the pattern in terms of share of land was similar in plateau and valley sites, despite the much smaller farm sizes in the valley.

Cropping Pattern with Hybrid Maize Adoption

A comparison of the cropping pattern of hybrid maize adopters with that of the nonadopters in the plateau shows that adopters sow an even larger area to local maize than the nonadopters: 1.7 hectares, compared with 1.3 hectares for nonadopters

Table 5— Crop area and share, by site

Crop Area/Share	Agriculture Districts										
	Mambwe	Chama	Lundazi, Chipili	Lundazi, Kasendeka	Chipata, North	Chipata, South	Chadiza	Katete	Petauke	Nyimba	All
Number	33	30	33	33	29	33	33	26	32	32	314
	(hectares/household)										
Maize											
Local maize											
Sole crop	0.03	0.36	0.46	0.25	0.11	0.35	0.05	0.03	1.36	1.31	0.44
Percent	2.63	48.00	21.50	6.65	10.19	18.32	2.09	1.35	76.84	41.59	21.46
Intercrop	0.65	0.02	0.74	1.64	0.69	0.62	1.32	2.03	0.03	0.31	0.79
Percent	57.02	2.67	34.58	43.62	63.89	32.46	55.23	91.03	1.69	9.84	38.54
Total	0.68	0.38	1.20	1.89	0.79	0.97	1.37	2.06	1.40	1.62	1.23
Percent	59.65	50.67	56.07	50.27	73.15	50.79	57.32	92.38	79.10	51.43	60.00
Hybrid maize											
Sole crop	0.00	0.06	0.34	1.00	0.10	0.45	0.08	0.04	0.09	0.94	0.32
Percent	0.00	8.00	15.89	26.60	9.26	23.56	3.35	1.79	5.08	29.84	15.61
Intercrop	0.00	0.00	0.07	0.33	0.00	0.17	0.76	0.00	0.00	0.23	0.16
Percent	0.00	0.00	3.27	8.78	0.00	8.90	31.80	0.00	0.00	7.30	7.80
Total	0.00	0.06	0.41	1.33	0.10	0.62	0.84	0.04	0.09	1.18	0.48
Percent	0.00	8.00	19.16	35.37	9.26	32.46	35.15	1.79	5.08	37.46	23.41
Total maize	0.68	0.44	1.61	3.23	0.89	1.59	2.21	2.10	1.49	2.79	1.71
Percent	59.65	58.67	75.23	85.90	82.41	83.25	92.47	94.17	84.18	82.57	83.41
Other cereals	0.27	0.18	0.26	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Percent	23.68	24.00	12.15	6.38	0.00	0.00	0.00	0.00	0.00	0.00	4.88
Groundnuts and legumes	0.09	0.12	0.13	0.11	0.08	0.31	0.12	0.13	0.19	0.30	0.16
Percent	7.89	16.00	6.07	2.93	7.41	16.23	5.02	5.83	10.73	9.52	7.80
Cotton and sunflower	0.06	0.00	0.14	0.19	0.07	0.01	0.05	0.00	0.06	0.05	0.07
Percent	5.26	0.00	6.54	5.05	6.48	0.52	2.09	0.00	3.39	1.59	3.41
Miscellaneous	0.03	0.02	0.01	0.00	0.03	0.00	0.01	0.00	0.02	0.00	0.01
Percent	2.63	2.67	0.47	0.00	2.78	0.00	0.21	0.00	1.13	0.00	0.49
Total area	1.14	0.75	2.14	3.76	1.08	1.91	2.39	2.23	1.77	3.15	2.05
Percent	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Table 6—Crop area and share, by region

Crop Area/Share	Region		
	Plateau	Valley	All
Number of households	251	63	314
Maize		(hectares/household)	
Local maize			
Sole crop	0.50	0.19	0.44
Percent	21.55	19.77	21.46
Intercrop	0.90	0.35	0.79
Percent	38.79	36.46	38.54
Total	1.40	0.54	1.23
Percent	60.34	56.25	60.00
Hybrid maize			
Sole crop	0.40	0.03	0.32
Percent	17.24	3.13	15.61
Intercrop	0.20	0.00	0.16
Percent	8.62	0.00	7.80
Total	0.60	0.03	0.48
Percent	25.86	3.13	23.41
Total maize	2.00	0.57	1.71
Percent	86.21	59.38	83.41
Other cereals	0.06	0.23	0.10
Percent	2.59	23.96	4.88
Groundnuts and legumes	0.17	0.10	0.16
Percent	7.33	10.42	7.80
Cotton and sunflower	0.08	0.03	0.07
Percent	3.45	3.13	3.41
Miscellaneous	0.01	0.03	0.01
Percent	0.43	3.13	0.49
Total	2.32	0.96	2.05
Percent	100.00	100.00	100.00

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

(Table 7). On average, the adopting households were putting slightly more area under local maize than under hybrid and, overall, had 88 percent of their land under maize, compared with 83 percent for nonadopting plateau households and 60 percent for valley households. These observations should be related to the significantly higher farm size of adopting households: 3.7 hectares, compared with 1.6 hectares for nonadopting plateau households and only 1 hectare for valley households.

This pattern of area allocation, indicating a preferential treatment of local maize despite a presumably higher profitability for hybrid maize, is similar to acreage allocations to cash crops observed in other countries in Sub-Saharan Africa.[14] Similar results are not found in situations with better market integration, the Philippines, for

[14]This was found for sugar-producing farmers in South Nyanza District of Kenya by Kennedy and Cogill (1987) and for potato-producing farmers in Rwanda by von Braun, de Haen, and Blanken (1991).

Table 7—Crop area and share, by hybrid maize adoption

Crop Area/Share	Plateau Nonadopters	Plateau Adopters	Valley	All
Number of households	154	93	63	310
Maize		(hectares/household)		
Local maize				
Sole crop	0.44	0.62	0.19	0.44
Percent	28.39	16.71	19.79	21.15
Intercrop	0.84	1.04	0.35	0.80
Percent	54.19	28.03	36.46	38.46
Total	1.28	1.66	0.54	1.25
Percent	82.58	44.74	56.25	60.10
Hybrid maize				
Sole crop	0.00	1.07	0.03	0.33
Percent	0.00	28.84	3.13	15.87
Intercrop	0.00	0.55	0.00	0.17
Percent	0.00	14.82	0.00	8.17
Total	0.00	1.62	0.03	0.49
Percent	0.00	43.67	3.13	23.56
Total maize	1.28	3.28	0.57	1.74
Percent	82.58	88.41	59.38	83.65
Other cereals	0.04	0.11	0.23	0.10
Percent	2.58	2.96	23.96	4.81
Groundnuts and legumes	0.15	0.22	0.10	0.16
Percent	9.68	5.93	10.42	7.69
Cotton and sunflower	0.07	0.09	0.03	0.07
Percent	4.52	2.43	3.13	3.37
Miscellaneous	0.01	0.00	0.03	0.01
Percent	0.65	0.10	3.13	0.48
Total	1.55	3.71	0.96	2.08

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

example, where purchased staples are preferred (Bouis and Haddad 1990). A study in Guatemala where export crop production was introduced found a slight reduction in area farmed to food crops, but this was offset by a substantial increase in use of improved inputs in food crop production and higher yields (von Braun, Hotchkiss, and Immink 1989). In Zambia, rural households have several reasons for treating hybrid maize predominantly like a cash crop, and as discussed in Chapter 2, this is along the lines of national policy objectives of promoting surplus production for urban areas. However, in the long run, these policies may have been self-defeating, as they have not encouraged production of hybrid maize for home consumption—which could have led to a much higher marketed production of maize than has hitherto been possible.

Whereas hybrid maize-adopting households specialize more in maize than other households, they also have a higher area under secondary cereals, which, on the plateau, is predominantly finger millet. These households slightly reduce their share of land under legumes and the secondary cash crops (cotton and sunflower), but in absolute terms land devoted to these crops is still higher than that allocated by the nonadopting households.

5

CHARACTERISTICS AND DETERMINANTS OF HYBRID MAIZE ADOPTION

In this chapter, some agricultural production characteristics of hybrid maize-adopting households are examined and some conclusions drawn on household income effects and possible changes in intrahousehold control of income with hybrid maize adoption. In particular, the role of increasing farm size, especially with oxen cultivation (which permits area expansion), in hybrid maize adoption is examined. Allocation of fertilizer to different crops and fertilizer use strategies are also examined, as are differences in intrahousehold control of crop production. In order to predict the effect of hybrid maize adoption on household income, an estimation equation is fitted for predicting changes in household per capita consumption expenditure with adoption of hybrid maize.

Hybrid Maize Adoption by Farm Size

In 1986, only 30 percent of the farmers in the smallholder sector in Eastern Province had adopted hybrid maize. Among the nonadopters were virtually all the farmers living in the valley areas and more than 60 percent of the farmers in the plateau areas. In area planted, hybrid maize accounted for only 28 percent of maize area. This is much lower than the 64 percent area under hybrid maize reported for the country as a whole for that year (CIMMYT 1987).

Adoption of hybrid maize was found to be heavily concentrated among the 10 percent of farmers with the largest farms in Eastern Province—all of the plateau farmers with more than 5 hectares grew the hybrid (Table 8). However, adoption was substantial among the smaller-size farms as well. About 53 percent of the farmers in the 3-to-5-hectare category, 43 percent in the 2-to-3-hectare category, and 24 percent in the 1-to-2-hectare category grew the improved varieties. In the smallest farm size, less than 1 hectare, adoption was minimal. In the valley, there was virtually no adoption of the hybrid because of the small farm sizes and a relatively favorable climate for other cash crops, such as cotton and sunflower.

In an earlier IFPRI survey in the area in 1981/82, use of hybrid maize in valley areas that were part of the Intensive Development Zone (IDZ) Program of the 1970s was noticeably higher, along with other commercial crops, especially cotton and soybeans. By 1986, production of both hybrid maize and soybeans in the valley areas had declined appreciably. This is attributed to the availability of tractors for field preparation during the earlier period provided by the local agricultural offices in IDZ areas. The disrepair of this equipment in subsequent years and the shift of policies away from the IDZ concept probably made it difficult for the farmers in the valley to enlarge farm size and plant the hybrid maize crop.[15] Cotton production, on the other

[15]Trypanosomiasis, a parasitic livestock disease transmitted by the tsetse fly, is endemic in the valley. This prevents households in that area from keeping livestock and engaging in ox-drawn plow cultivation.

Table 8—Hybrid maize adoption by farm size, plateau and valley

Area/ Adoption	Farm Size in Hectares per Household: Less than 1 (N)	(percent)	1 - 2 (N)	(percent)	2 - 3 (N)	(percent)	3 - 5 (N)	(percent)	More than 5 (N)	(percent)	Total (N)	Weighted Average (percent)
Plateau												
Nonadopter	64	57.7	50	56.2	19	47.5	21	44.7	0	0.0	154	49.7
Adopter	7	6.3	21	23.6	17	42.5	25	53.2	23	100.0	93	30.0
Valley												
Nonadopter	40	36.0	18	20.0	4	10.0	1	2.1	0	0.0	63	20.3
Total	111	100.0	89	100.0	40	100.0	47	100.0	23	100.0	310	100.0

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Notes: Numbers may not add to 100 due to rounding. N is sample size.

hand, is preferred by the smaller farmers for various reasons, including the prompt payment by LINTCO, the cotton parastatal, to farmers for their crop.

Area expansion (and factors contributing to it) has generally been accepted as an important contributor to hybrid maize adoption in Zambia. Jha and Hojjati (1993), in their model of fertilizer use in Eastern Province, postulated a simultaneously determined area farmed and a hybrid maize use function. In another study, Jha, Hojjati, and Vosti (1991) found area expansion to be the single most important determinant of hybrid maize adoption. At the mean, expansion of area by 1.0 hectare meant the probability of adopting hybrid maize was nearly 0.8. Two factors that could contribute to this finding are (1) food security considerations of households and (2) access to inputs such as improved seed and chemical fertilizers. The limited types of improved maize seed available[16] as well as the maize pricing and marketing policies in effect at the time are likely to be the main contributing factors to this pattern of adoption. Limited access to or demand for improved inputs does not appear to be as much of a limiting factor as the supply-side and distribution problems (Keller and Mbewe 1988). Fertilizer application was much more widespread than was hybrid maize seed. This was especially so in areas with a high level of hybrid maize adoption (Jha and Hojjati 1993). To a large extent, the supply-side variations were a function of the effectiveness of local chapters of the Eastern Province Cooperative Union in obtaining and distributing the inputs.

Hybrid Maize Adoption and Oxen Use

That the availability of mechanical traction for cultivation is a factor in the ability of farmers to increase their farm size, and thereby to grow hybrid maize, was confirmed in a recent analysis of Eastern Province by Jha and Hojjati (1993). They found that oxen cultivators farm an additional 1.4 hectares and have a 0.9 probability that

[16]SR52 was the main type of hybrid available. Since it is a hybrid, it has to be purchased annually, and it is a long-duration variety. It therefore competes with planting of local maize. It is also a "dent" variety, that is, it has a soft kernel that is difficult to store and process with traditional technologies.

Table 9—Oxen use by farm size

Oxen Use	Farm Size in Hectares per Household: Less than 1 (N)	(percent)	1 - 2 (N)	(percent)	2 - 3 (N)	(percent)	3 - 5 (N)	(percent)	More than 5 (N)	(percent)	Total (N)	Average Share of Total Farms (percent)
Use oxen	23	20.7	39	43.8	23	57.5	42	89.4	22	95.7	149	48.1
Do not use oxen	88	79.3	50	56.2	17	42.5	5	10.6	1	4.3	161	51.9
Total	111	100.0	89	100.0	40	100.0	47	100.0	23	100.0	310	100.0

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Note: N is sample size.

they will grow hybrid maize. Although in recent years the perception of a land frontier has become more real in the minds of farmers interviewed, virtually all of them still claim that they could expand the size of their farms if they chose. This is a reflection of the availability of fallow land rather than their capacity to cultivate more land.

It is the ability to use oxen to expand area planted that apparently drives the association with hybrid maize production, rather than oxen use per se (Tables 9 and 10). The share of farmers using oxen cultivation increases rapidly with farm size, with 96 percent of the households with more than 5 hectares using oxen. At the other end, only 21 percent of the smallest farms cultivate with oxen (Table 9). Among the farmers not growing hybrid maize, oxen users nearly equal those not using oxen, while among the adopters, 82 percent use oxen (Table 10). In order to expand cultivated area, farmers also need more workers; in areas where the labor market is thin, this means a larger family. Without the assured labor supply, farmers hesitate to expand cultivated areas (Kumar 1988).

As might be expected, no oxen are used in the valley areas because of the presence of the tsetse fly, which spreads trypanosomiasis. Hybrid maize production in valley areas was more widespread in the early 1980s, when some IDZ areas were

Table 10—Oxen use by hybrid maize adoption

Area/Hybrid Maize Use	Use Oxen (N)	(percent)	Do Not Use Oxen (N)	(percent)	Total (N)	Percent of Sample Households (percent)
Plateau						
Nonadopters	73	49.0	81	50.3	154	49.7
Adopters	76	51.0	17	10.6	93	30.8
Valley						
Nonadopters	0	0.0	63	39.1	63	19.5
All	149	100.0	161	100.0	310	100.0

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Note: N is sample size.

located there.[17] A previous IFPRI study found 13 percent of maize area in the Jumbe-Chikowa area of the valley planted in hybrids in 1980/81 and 10.5 percent in 1981/82 (IFPRI/NFNC/RDSB 1985).

Hybrid Maize Adoption by Male or Female Household Heads

Female-headed households accounted for 30 percent of all households included in the study. This figure is in line with the 32 percent of farm households legally headed by women in Eastern Province in a 1982/83 farm survey of Zambia (Safilios-Rothschild 1985). Due to limited male-only outmigration, de facto female heads are not present, except on a seasonal basis. Since the majority of the rural female-headed households are primarily engaged in agriculture, from an agricultural policy perspective, they should be considered important in design and implementation of development activities.

Evaluations of agricultural development programs in Zambia have generally concluded that female-headed households were underrepresented as beneficiaries of these programs (Due and White 1986; Bliven 1991). More recently, in some provinces, such as Eastern and Northern, funds for credit were set aside for women and made available to members of women's clubs in the Lima agricultural program. Although these amounts were insufficient relative to the proportion of women involved in agriculture (either as female heads of households or as wives), they still represent an improvement over standard practices. Nevertheless, only 12 percent of female heads in these provinces participated in the Lima program (IRDP 1983).

For the sample as a whole, in 1986 female-headed households had a lower rate for adoption of hybrid maize (22 percent) than male-headed households (34 percent). However, the pattern is not the same across farm sizes (Table 11). Except for the smallest farm category, in which adoption is minimal in both male- and female-headed households, the pattern for the next two groups is different from that of the two largest farm size groups. In the 1-to-3-hectare sizes, female-headed households have a much *lower* rate of adoption than the male-headed households. This is consistent with the overall pattern and is also reported in most of the technological change and commercialization literature. Surprisingly, however, female-headed households in the 3-to-5-hectare category have a *higher* adoption rate than male-headed households, and all households over 5 hectares are adopters. This difference by farm size implies that once women are able to overcome resource constraints, they are just as likely or even more likely to become technological innovators. However, when they are faced with resource constraints, women are less likely to adopt new technology, either because they tend to be more risk averse or because they face greater hurdles in obtaining technological inputs or other requirements for adopting improved technologies.

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[17]Areas that were designated to be part of the IDZ program included some districts in the Luangwa Valley, where farmers received access to tractors for field preparation in addition to seeds, fertilizer, and extension.

Table 11—Farm size and hybrid maize adoption by head of household

Head of Household	Less than 1 (N)	Less than 1 (percent)	1 - 2 (N)	1 - 2 (percent)	2 - 3 (N)	2 - 3 (percent)	3 - 5 (N)	3 - 5 (percent)	More than 5 (N)	More than 5 (percent)	Total (N)	Percent of Sample Households (percent)
Male												
Nonadopter	69	62.2	41	46.1	16	40.0	17	36.2	0	0.0	143	46.1
Adopter	5	4.5	20	22.5	16	40.0	18	38.3	16	69.6	75	24.2
Female												
Nonadopter	35	31.5	26	29.2	6	15.0	5	10.6	0	0.0	72	23.2
Adopter	2	1.8	2	2.2	2	5.0	7	14.9	7	30.4	20	6.5
All	111	100.0	89	100.0	40	100.0	47	100.0	23	100.0	310	100.0

(Farm Size in Hectares per Household)

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Note: N is sample size.

Demographic characteristics of female-headed households by farm size offer some possible explanations. In general, for both male- and female-headed households, as farm size increases, so does household size. While male-headed households have a significantly larger number of male adults, female-headed households have a larger number of female adults. As farm size increases, however, there is a statistically significant increase in male adults, female adults, and children in male-headed households, but for female-headed households, the increase in adult males (15 years old or more) is especially marked. The only other demographic difference is that the age of female heads is significantly lower than male heads in the larger farm households. Female heads cultivating 3 or more hectares are, on average, seven years younger than male household heads cultivating 3 hectares or more.

Analysis of Hybrid Maize Adoption and Its Income Effects

Analysis of factors contributing to the adoption of improved agricultural technologies for this sample of households in Eastern Province was also conducted by Jha and Hojjati (1993) and by Jha, Hojjati, and Vosti (1991). In addition to results confirming that area expansion is conducive to adoption of hybrid maize and facilitated by use of animal traction and increase in family size, they found increased length of residence in the area also to be a factor.[18] Other factors contributing to hybrid maize adoption included membership in the cooperative Eastern Province Cooperative Union (EPCU), age of head of household (younger households were more likely to be adopters), and gender of head of household (male heads were more likely to be adopters). Access to markets and infrastructure was not a factor.

[18]For background information on land tenure in Eastern Province, see Milimo (1991). Conversations with farmers during the study suggest that most had access to fallow land.

In contrast to hybrid maize adoption, fertilizer use was more widespread and was adopted by twice as many farmers as was hybrid maize. Jha and Hojjati (1993) did not find an increase in farm size to be a predictor for fertilizer use. However, intensity of fertilizer use was clearly associated with hybrid maize adoption. This is reflected in the relative frequency of fertilizer use on hybrid versus local maize fields as well as in the higher rate of application on hybrid maize. Fertilizer was applied on virtually all hybrid maize fields but only on 47 percent of local maize fields. In terms of rate of fertilizer application, however, hybrids received only 50 percent more fertilizer (nutrients) per fertilized hectare than local maize. According to field trials conducted by the Eastern Province Agricultural Research Station, this incremental fertilizer application on hybrid maize is consistent with the relative yield response and value-cost ratio for its application on hybrid versus local maize. No other crops besides maize received any inorganic fertilizer application in the study year.[19]

In order to derive the income effects of hybrid maize adoption, the problem of endogeneity of the measured adoption behavior needed in this report has to be resolved. That data from only one crop season are available compounds the problem. Exogenous variables that are not influenced by adoption are therefore used as predictors of adoption behavior. The results of the Heckman two-stage model, estimating the acreage planted to hybrid maize, as described in Chapter 3, are presented in Table 12. Predicted values for adoption are then used to explain variations in household income. In estimating the effects of hybrid maize adoption on income, both the predicted values for its adoption per se and area planted to it are used in addition to other explanatory variables. Total consumption expenditure is used as a proxy for disposable income.[20]

Results of the predicting equations for hybrid maize adoption show the same signs and significance as work done earlier by Jha, Hojjati, and Vosti (1991). The next set of results examines the income effects of hybrid maize adoption at different farm sizes.

The analysis of the impact of hybrid maize on income and consumption expenditures is complicated by the fact that (1) its adoption is collinear with increase in farm size, and (2) its effect on income can be decomposed into two components: the effect of adoption and the effect of increasing area under the hybrid. In order to incorporate all of these factors, three cultivated area variables are modeled on the right-hand side of the income equation:

- Size of total area farmed (*TOTHA*);
- Predicted area planted to hybrid maize in hectares (*FAREAHMZ*); and
- Square of predicted area planted to hybrid maize (*FAREAHMZ* x *FAREAHMZ* = *PAREASQ*).

Other variables are household demographics, education, and ecological zones. Per capita and total household consumption expenditure are used as a proxy for disposable income.

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[19]Application of organic manure is limited to a small fraction of plots on which animals are "corralled" (fenced in for extended periods of time). Only six fields were corralled during the study period, three of which were planted in local maize, two in legumes, and one in hybrid maize.

[20]Consumption expenditure is commonly used as an indicator of household welfare and is more likely to predict permanent income than short-term income measures (Glewwe 1990).

Table 12— Determinants of hybrid maize adoption and its income effects

Independent Variable	Mean	Probability of Hybrid Maize Adoption, Mean = 0.29		Area Under Hybrid Maize (Conditional on Adoption), Mean = 1.7		Per Capita Consumption Expenditure Per Month, Mean = 3.9		Total Consumption Expenditure Per Month, Mean = 5.6	
		Coefficient	t-Ratio	Coefficient	t-Ratio	Coefficient	t-Ratio	Coefficient	t-Ratio
AGEHEAD	43.6	−0.0208	−2.55*	−0.0322	−2.93*	−0.0016	−1.01	−0.0028	−1.60
FAMILSZ2	5.9	0.0115	0.28	0.0035	0.08	−0.1101	−13.37*	0.0547	6.29*
HEADHH	0.7	0.6448	2.38*	1.0042	3.14*	0.0347	0.71	0.0781	1.50
DEPRATIO	1.1	...	...	...	...	−0.0773	−3.08*	−0.0328	−1.24
EDHHLD	3.6	0.0483	1.39	−0.0124	−0.28	0.0147	2.01	0.0141	1.82
COOPMEM	0.2	0.1664	0.61	0.7418	2.69*	...	...	...	...
DUMPLAT1	0.4	0.4978	1.20	−0.4725	−0.54	...	...	...	...
DUMPLAT2	0.4	1.4351	3.41*	0.4084	0.43	...	...	...	...
OXEN	0.5	0.0039	0.02	0.0832	0.24	...	...	...	...
VALLPLAT	0.2	...	...	...	...	0.3376	6.17*	0.3711	6.43*
THa	2.1	0.5251	5.86*	0.6299	8.80*	0.0310	1.45	0.0426	1.89
TOTINOTH	115.1	−0.0001	−0.31	0.00003	0.12	...	...	...	...
AREADINF	1.3	0.1651	1.49	0.0353	0.25	...	...	...	...
MILLS1	0.7	...	...	0.8871	2.18*	...	...	...	...
FAREAHMZ	0.5	...	...	...	...	0.1511	3.31*	0.1668	3.47*
PAREASQ	1.6	...	...	...	...	−0.0153	−2.94*	−0.0223	−4.07*
Constant		−2.70	−4.41*	−1.26	−0.92	4.4818	49.80*	5.1063	53.82*
R^2 (adjusted)		0.39		0.67		0.49		0.35	
F		18.3		15.7		33.0		19.0	
Sample size		304		88		304		304	

Notes: Variable definitions:

AGEHEAD = Age of household head
FAMILSZ2 = Family size
HEADHH = Sex of the household head: 1 = male, 0 = female
DEPRATIO = Dependency ratio: +60/14-60
EDHHLD = Education of the household head: grades completed
COOPMEM = Membership in cooperatives: 1 = yes, 0 = no
DUMPLAT1 = Dummy area level low adoption: 1 = low
DUMPLAT2 = Dummy area level high adoption: 1 = high
OXEN = Cultivation method dummy: 1 = oxen use
VALLPLAT = Valley or plateau: 1 = valley, 0 = plateau
THa = Total area farmed: hectares per household
TOTINOTH = Income from other sources (kwacha per household per year)
AREADINF = Area level infrastructure index based on distance to 12 elements (the higher the index, the poorer the infrastructure)
MILLS1 = Inverse mills ratio
FAREAHMZ = Predicted area under hybrid maize: hectares per household
PAREASQ = FAREAHMZ × FAREAHMZ (the square of predicted area under hybrid maize)

The ellipses indicate a nil or negligible amount.
*Significant at the .05 level.

The results of this analysis indicate that increasing both farm size and area under the hybrid have a positive effect on household income. Increasing area under hybrid maize has a much higher effect, as is to be expected. However, the variable for hybrid maize area squared (PAREASQ) has a statistically significant negative sign, indicating a higher potential for income increments at the smaller farm sizes but diminishing returns beyond a certain point of expansion of area under hybrid maize. In order to derive the inflection point, the point at which $\eta = 0$ (η = elasticity) is calculated. When

$$y = \alpha + \beta x + \gamma x^2 + u, \tag{13}$$

then

$$\eta = (\beta y + 2\gamma x \cdot y)(x/y), \tag{14}$$

at $\eta = 0$, $x = -\beta/2\gamma$.[21] The inflection point for both per capita and household income equations is 4 hectares of hybrid maize, indicating that planting larger acreages is inefficient.

There are several possible explanations for the negative quadratic sign on hybrid maize area. First, hybrid maize may change intrahousehold interactions, so that even though the return to households in per capita terms declines, gains to individuals who control the crop may be higher. This may be an important factor in low productivity improvements overall and related to the deterioration in women's access to resources that sometimes occurs with hybrid maize adoption.[22] This aspect is explored further in the next section. Other explanations that have been proposed for this kind of result are that subsidized inputs available to larger farmers, including credit and improved seeds and fertilizers, distort the resource allocation patterns and, in effect, support farmers who may be less productive than others.[23]

These results are mirrored later in the food consumption and child nutrition results, where large farms adopting hybrid maize have a lower level of food consumption and child nutrition than large, nonadopting farms, while adoption is positively related to these effects on small farms. (The cutoff point for each farm size group is the median for the sample of adopting and nonadopting farms.)

- Farm Size
  - Adopters
    - Small: 1.46 hectares
    - Large: 4.39 hectares
  - Nonadopters
    - Small: 1.22 hectares
    - Large: 3.01 hectares

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[21]The following adjustments were made in the values of the regression coefficients for hybrid maize area and hybrid maize area squared to accommodate the log value of the dependent variable. When the equation $\log y = \alpha + \beta^* x + \gamma^* x$ squared is estimated, β and γ can be calculated at the mean value of the dependent variable as follows:

$$\beta = \text{antilog}(\log y + \beta^*) - \text{antilog}\, y,$$
$$\gamma = \text{antilog}(\log y + \gamma^*) - \text{antilog}\, y,$$
and at $\eta = 0$, $x = (-\beta)/2\gamma$.

[22]Milimo (1989) also refers to women's insecure access to land as a source of low agricultural productivity in Zambia.

[23]Yadav, Otsuka, and David (1992) have observed this in Nepal.

Other variables contributing to increased disposable income are education of head of household and having a male head of household, Valley households have a significantly higher level of consumption expenditure than plateau households. Increasing household size benefits total household income but reduces per capita income. A higher dependency ratio lowers both per capita and household income.

Intrahousehold Dimensions of Agriculture

As part of the crop production study, information on the person who owned or managed each plot of land was obtained. This makes it possible to examine the extent of women's responsibility and ownership of different crops. For the Eastern Province sample as a whole, the results in Table 13 show the extent to which women are responsible, either on their own or jointly with others, for different crops. For local maize and other cereals, about one-fifth of the land is independently managed by women, and an additional one-third is jointly managed with men. Overall, nearly 57 percent of local maize and 70 percent of other cereals are independently or jointly managed by women.

Table 13—Women's crop ownership and share

Crop/Share[a]	Total Area Farmed	Area Farmed by Women		
		Independently	Jointly	Independently and Jointly
		(hectares/household)		
Maize				
Local maize				
Sole crop	0.44	0.08	0.14	0.22
Share	...	0.18	0.32	0.50
Intercrop	0.79	0.19	0.30	0.49
Share	...	0.24	0.38	0.62
Total	1.23	0.26	0.44	0.70
Share	...	0.21	0.36	0.57
Hybrid maize				
Sole crop	0.32	0.01	0.08	0.09
Share	...	0.03	0.25	0.28
Intercrop	0.16	0.02	0.01	0.03
Share	...	0.13	0.06	0.19
Total	0.48	0.03	0.09	0.12
Share	...	0.06	0.19	0.25
Total maize	1.71	0.30	0.54	0.84
Share	...	0.18	0.32	0.50
Other cereals	0.10	0.02	0.03	0.05
Share	...	0.20	0.30	0.70
Groundnuts and legumes	0.16	0.02	0.06	0.03
Share	...	0.13	0.38	0.51
Cotton and sunflower	0.07	0.00	0.02	0.02
Share	...	0.00	0.29	0.29
All crops	2.04	0.34	0.65	0.99
Share	...	0.17	0.32	0.49

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

[a]Crops are in hectares of area farmed and shares are the percentages of the total area farmed by women.

Hybrid maize is similar to the other cash crops, cotton and sunflower, in that much less is under women's control. Only 25 percent of hybrid maize area is independently or jointly managed by women. About 51 percent of the land in groundnuts and other legumes, is managed by women. Of the total area farmed, 17 percent is farmed independently and 32 percent jointly by women for a total share of 49 percent.

When the pattern of crop ownership is considered by head of household, there are differences between male- and female-headed households (Table 14). As might be expected, in female-headed households, women farm a substantially larger share of land—63 percent of the land independently and 22 percent jointly with men.

Women in male-headed households cultivate an insignificant amount of land independently: only 4.5 percent. The share for local maize is only slightly higher than the overall average. It is significant to note that the secondary (other) cereals (which are also the traditionally grown cereals, such as finger millet, sorghum, and rice) have the highest share of independent cultivation by women, about 19 percent in male-headed households. A substantial share of land, 43.5 percent, in male-headed households is jointly farmed by women. Of all the crops, hybrid maize has the smallest share of management by women, but it is still a substantial 31 percent. In female-headed households, women manage (independently or jointly) 47 percent of the area under hybrid maize.

The pattern of intrahousehold crop ownership indicates that women have little independent ownership except in female-headed households. Secondary cereal crops that are likely to have been traditionally grown by women (or have little commercial appeal) are most likely to be managed independently by them in male-headed households. However, 48 percent of the land in male-headed households and 85 percent of the land in female-headed households is independently *or* jointly managed by women. The crop with the smallest share of women's management is hybrid maize, but even in that, 31 percent of land in male-headed and 47 percent in female-headed households are independently or jointly managed by them.

Women's Involvement in Crop Management With Hybrid Maize Adoption

The concept of separate crop ownership for different plots of land farmed by a household is well known and accepted in Zambia's Eastern Province, where the traditional land tenure system predominates. This is similar to usufruct rights to land and is distinct from land ownership. Milimo (1991) observes that the concept of individual land ownership does not exist in the traditional land tenure system in this area. Since both patrilineal and matrilineal systems coexist in Eastern Province, land that has been assigned to the extended family is passed on to the next generation either through the father or the mother.

Within the household itself, farming responsibility is divided between members, with output produced in the household's fields the predominant food source. This is generally local maize, which is usually jointly owned by husbands and wives. Other fields may be cropped with primary responsibility for output resting with an individual. This assignment may depend on the perceived role of the individual; for example, women traditionally have the responsibility for providing the "relish" ingredients for the meal, which could include groundnuts, leafy vegetables, fish, or meat. Output from

Table 14—Women's crop ownership and share, by household head

Crop	Number in Total Sample	Male-Headed Household[a] Total Area	Male-Headed Household[a] Percent of Area	Male-Headed Household[a] Area Farmed Indepen-dently	Male-Headed Household[a] Percent of Area Farmed Indepen-dently	Male-Headed Household[a] Area Farmed Jointly	Male-Headed Household[a] Percent of Area Farmed Jointly	Female-Headed Household Total Area	Female-Headed Household Percent of Area	Female-Headed Household Area Farmed Indepen-dently	Female-Headed Household Percent of Area Farmed Indepen-dently	Female-Headed Household Area Farmed Jointly	Female-Headed Household Percent of Area Farmed Jointly
		(hectares)		(hectares)		(hectares)		(hectares)		(hectares)		(hectares)	
Maize													
Local maize													
Sole crop	123	1.10	56.0	0.08	6.7	0.32	39.1	1.14	68.3	0.54	55.4	0.49	32.3
		(92)	(92)	(92)	(92)	(92)	(92)	(31)	(31)	(31)	(31)	(31)	(31)
Intercrop	197	1.20	66.0	0.07	5.7	0.58	50.9	1.40	75.0	0.75	70.6	0.27	14.3
		(131)	(131)	(131)	(131)	(131)	(131)	(66)	(66)	(66)	(66)	(66)	(66)
Total	299	1.30	66.3	0.08	6.1	0.51	46.0	1.40	77.6	0.73	64.5	0.36	21.2
		(208)	(208)	(208)	(208)	(208)	(208)	(91)	(91)	(91)	(91)	(91)	(91)
Hybrid maize													
Sole crop	59	1.70	44.0	0.08	2.7	0.42	34.9	1.60	27.7	0.06	20.0	0.44	20.0
		(49)	(49)	(49)	(49)	(49)	(49)	(10)	(10)	(10)	(10)	(10)	(10)
Intercrop	35	1.50	45.3	0.02	3.7	0.17	13.8	1.40	35.4	0.72	50.0	0.00	0.0
		(27)	(27)	(27)	(27)	(27)	(27)	(8)	(8)	(8)	(8)	(8)	(8)
Total	88	1.80	47.7	0.06	2.0	0.36	29.0	1.60	33.0	0.38	35.3	0.26	11.8
		(71)	(71)	(71)	(71)	(71)	(71)	(17)	(17)	(17)	(17)	(17)	(17)
Total maize	307	1.80	79.6	0.10	4.1	0.61	44.6	1.70	83.8	0.80	64.3	0.41	21.1
		(216)	(216)	(216)	(216)	(216)	(216)	(91)	(91)	(91)	(91)	(91)	(91)
Other cereals	60	0.51	30.8	0.06	18.8	0.15	38.7	0.49	31.0	0.14	31.3	0.14	18.8
		(44)	(44)	(44)	(44)	(44)	(44)	(16)	(16)	(16)	(16)	(16)	(16)
Groundnuts and legumes	183	0.29	17.7	0.01	6.4	0.11	41.3	0.23	15.0	0.13	71.4	0.07	22.4
		(134)	(134)	(134)	(134)	(134)	(134)	(49)	(49)	(49)	(49)	(49)	(49)
Cotton and sunflowers	53	0.38	18.9	0.01	2.8	0.12	38.9	0.41	15.7	0.06	25.9	0.13	32.9
		(36)	(36)	(36)	(36)	(36)	(36)	(17)	(17)	(17)	(17)	(17)	(17)
Miscellaneous	27	0.11	8.9	0.0004	2.2	0.03	34.3	0.27	18.3	0.26	75.0	0.01	25.0
		(23)	(23)	(23)	(23)	(23)	(23)	(4)	(4)	(4)	(4)	(4)	(4)
Total	310	2.10	100.0	0.12	4.5	0.72	43.5	1.90	100.0	0.90	63.1	0.49	21.7
		(218)	(218)	(218)	(218)	(218)	(218)	(92)	(92)	(92)	(92)	(92)	(92)

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Note: Numbers in parentheses are sample sizes.

[a]These are crops managed by women in households headed by males.

groundnut fields is therefore predominantly reported to be owned by women. Alternatively, individuals perceived to have a comparative advantage or familiarity with a crop, especially a new crop, may decide to cultivate that independently. This could be a factor in the predominance of hybrid maize fields independently owned by men.

Crop ownership by an individual for a particular field does not mean that labor is provided only by that person. He or she may request, demand, or cajole labor from other household members or kin, and this ability is very likely to be an important influence on the crop outcome. It does, however, give that individual a high degree of control of allocation of the output from that field. It also implies that the individual is primarily responsible for management of the crop on it.

Since hybrid maize is primarily raised on the plateau, a comparison of changes in women's involvement with its adoption is made only for the plateau sites. The total area farmed independently by women is the same in adopter and nonadopter households, but the area farmed jointly increases by about 50 percent with adoption (Table 15). This shows that women take on somewhat more responsibility for cultivation in absolute terms in adopter households. When these differences are seen in relation to the 2.5 times larger farm sizes cultivated in the adopting households, it becomes clear that the relative share of women's crop area increases less than proportionately with hybrid maize adoption. Thus, in nonadopting households, women have primary responsibility for about 31 percent of farm land and for an additional 38 percent of land that is farmed jointly with other household members, for a total of more than 69 percent. In contrast, in adopting households, women have primary responsibility for production on only about 12 percent of land and joint responsibility for an additional 30 percent, for a total of 42 percent. In the process, they reduce the area they farm independently in local maize and substitute that for an additional share of hybrid maize under joint production with men.

In order to test whether the reduction in women's share of crop ownership that is observed to be associated with hybrid maize adoption is a function of adoption or of other characteristics associated with it such as increased farm size, the following multivariate relationship is analyzed[24]:

$$Fs = f(HM^*, THa, Head, EG), \tag{15}$$

where

Fs = share of land under independent and joint production by females,
HM^* = predicted hybrid maize adoption,
THa = total farm size,
$Head$ = sex of head of household, and
EG = patrilineal or matrilineal ethnic group.

The results presented in Table 16 confirm that the effect of hybrid maize adoption is independent of the effect of increasing farm size, and adoption has a large impact in that it decreases the share of area farmed that is owned and managed by women, either independently or jointly. This impact is similar in size and direction to that of shifting from a female to a male head of household. However, holding other factors

[24]This analysis is limited to the plateau sites only.

Table 15—Women's crop ownership and share, by hybrid maize adoption, plateau

Crop/Share/ Number of Sample	Hybrid Maize Adopted: Total Area	Hybrid Maize Adopted: Area Farmed Independently	Hybrid Maize Adopted: Area Farmed Jointly	Hybrid Maize Not Adopted: Total Area	Hybrid Maize Not Adopted: Area Farmed Independently	Hybrid Maize Not Adopted: Area Farmed Jointly
	(hectares/household)					
Maize						
Local maize						
Sole crop	1.75	0.17	0.61	1.20	0.28	0.33
Percent	41.0	12.0	33.3	73.2	26.6	31.0
N	(33)	(33)	(33)	(58)	(58)	(58)
Intercrop	1.60	0.32	0.41	1.20	0.35	0.56
Percent	48.2	20.2	29.5	80.4	35.1	42.1
N	(61)	(61)	(61)	(106)	(106)	(106)
Total	1.80	0.29	0.52	1.30	0.35	0.51
Percent	49.9	17.7	31.4	83.4	31.1	38.8
N	(86)	(86)	(86)	(153)	(153)	(153)
Hybrid maize						
Sole crop	1.74	0.08	0.44	0.00	0.00	0.00
Percent	40.8	5.8	33.5	00.0	00.0	00.0
N	(57)	(57)	(57)	(0)	(0)	(0)
Intercrop	1.50	0.18	0.13	0.00	0.00	0.00
Percent	43.0	14.3	10.6	00.0	00.0	00.0
N	(35)	(35)	(35)	(0)	(0)	(0)
Total	1.80	0.13	0.34	0.00	0.00	0.00
Percent	44.5	8.6	26.3	00.0	00.0	00.0
N	(86)	(86)	(86)	(0)	(0)	(0)
Total	3.30	0.39	0.80	1.30	0.35	0.51
Percent	87.4	13	29.6	83.4	31.1	38.8
N	(93)	(93)	(93)	(153)	(153)	(153)
Other cereals	0.73	0.02	0.11	0.46	0.17	0.07
Percent	18.7	7.1	28.6	19.7	38.5	15.4
N	(14)	(14)	(14)	(13)	(13)	(13)
Groundnuts and legumes	0.36	0.04	0.14	0.29	0.06	0.11
Percent	11.5	17.5	36.8	21.7	33.3	33.0
N	(57)	(57)	(57)	(80)	(80)	(80)
Cotton and sunflower	0.46	0.02	0.07	0.39	0.02	0.16
Percent	12.8	10.5	15.8	20.9	11.5	42.4
N	(19)	(19)	(19)	(26)	(26)	(26)
Miscellaneous	0.10	0.00	0.00	0.25	0.15	0.00
Percent	4.3	00.0	00.0	14.5	42.8	00.0
N	(3)	(3)	(3)	(7)	(7)	(7)
Total	3.70	0.42	0.92	1.50	0.41	0.60
Percent	100.0	12.3	29.7	100.0	30.6	37.7
N	(93)	(93)	(93)	(153)	(153)	(153)

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Note: The numbers (N) in parentheses are sample size.

constant, a greater share of women's crop area was found to be in patrilineal ethnic areas. The main ethnic groups in Eastern Province are the predominantly matrilineal Chewa and Nsenga in the southern and western districts of Petauke, Nyimba, Katete, Chadiza, (and the valley districts of Mambwe and Chama), and the patrilineal Ngoni and Tumbuka of the northern districts of Chipata North, Chipata South, and Lundazi. The higher share of women's crop area found in the patrilineal sites was surprising but may be related to a greater responsibility for production by the marriage partner who moves into the other's kinship land (Davison 1994; Crehan 1994). This may not

Table 16— Factors in women's management role

Independent Variable	Mean	Coefficient	t-Ratio
HEAD	0.69	−0.3276	−5.71*
THa	2.40	−0.0443	−0.29
HM*	0.29	−0.3203	−4.17*
EG	0.51	0.1663	3.19*
Constant	...	0.8219	13.90*
R^2 (adjusted)		0.26	
F		224.1*	
N		242	

Notes: The dependent variable is the proportion of area farmed by females independently and jointly. The variables are as follows:

HEAD = Sex of household head: 1 = male, 0 = female;
THa = Total area farmed: hectare per household;
HM* = Predicted hybrid maize adoption; and
EG = Ethnic group: 1 = patrilineal, 0 = matrilineal.

*Significant at the .05 level.

necessarily mean that women in patrilineal areas have better access to resources than those in matrilineal areas.

Implications for Agricultural Policy in Eastern Province

The analysis of adoption patterns of hybrid maize production and its effects on household income are generally positive, but the intrahousehold income benefits appear to be unevenly distributed between men and women—either as female heads or producers in male-headed households. The effects on interhousehold income distribution is mixed in that, while the smaller farmers had less access to adoption of hybrid maize, it was the smaller adopters that had the most income benefit from its adoption. Larger farms had a smaller income benefit from adoption of hybrid maize, and this is likely to be associated with labor shortages, inefficient use of inputs, and increasing intrahousehold inequity.

Overall, smaller farms and those headed by women are less likely to adopt the hybrid maize. This is because of their limited access to inputs, especially credit, seed, and fertilizer, which were available primarily through cooperative membership, and also their poorer access to extension and training services. Farmers who adopted hybrid maize experienced an overall improvement in their level of income in comparison with those who did not adopt, holding farm size constant. However, for farms cultivating more than 4.0 hectares of hybrid maize, the income gains from incremental acreage in hybrid maize were declining. One possible explanation for this counterintuitive result is the declining share of women's involvement in these farms (except on female-headed households) and, hence, their lower access to income gains. Since the intrahousehold control of hybrid maize income is expected to accrue primarily to the male members, especially the male heads of households, the reduction in disposable income gain for the household as a whole could occur even as area planted in hybrids is increasing.

In the past, the agricultural policy decisions in Zambia were made largely from the perspective of increasing marketed surplus of maize. This focus probably led to the observed patterns of adoption and effects. With the structural adjustment program and market liberalization efforts currently under way, the need to promote policies that are efficient in making productivity gains and that are sustainable becomes more crucial. One of the initial effects of the move away from the panterritorial pricing policies of the 1970s and 1980s will be a contraction of the geographical area where maize is produced for the market, which will only be profitable in the line-of-rail provinces and some adjoining areas. For the rest of the country, including Eastern Province and other outlying areas, agricultural policies will need to focus on making real productivity gains and in involving the private and nongovernmental sectors in making investments in services and infrastructure that will promote development in these areas.

The focus in the outlying provinces such as Eastern Province will need to be less on promoting larger farm sizes and more on increasing labor productivity and efficient use of inputs. Seeds, inputs, and extension approaches more suitable for dispersed populations of small farmers will need to be packaged according to the ecological, farm system, and consumption patterns that exist in these areas. Improved maize seed-fertilizer packages will remain integral to the agricultural growth needs in areas where its yield potential is above average, as in Eastern Province.

6

LABOR ALLOCATION PATTERNS

Understanding changes in patterns of labor allocation is an integral part of examining the effectiveness of technological change in agriculture. For small farmers such as those in Eastern Province, household labor is an important part of the production process as well as the welfare and consumption function, and thus it is central to their utility outcomes. Household production models and the theory of human capital have allowed economics to go beyond the work or leisure dichotomy in explaining the allocation of time (Becker 1965; Singh, Squire, and Strauss 1986). In these formulations, a household member's contribution to "full income" includes both disposable income and time. While income activities generate the primary resources, time spent on other activities is essential for the production of household goods and services (such as meals and child care) that directly enter into the household utility function. These activities are primarily undertaken by women. It follows from this that, as incomes go up, the demand for both commodities and time required for generating the final product could also increase (provided there is no improvement in technologies used in producing the Z-goods). This process is usually reflected in a substitution of women's labor from production to home consumption-related activities as incomes rise.

Technological change in agriculture can create competing demands for household labor. It may require additional time spent in agricultural production even while it generates an increase in household income. In this process, households may be adding to their food energy requirements as well as generating additional demand for labor in consumption and welfare support activities, the demand for which increases with incomes. The resulting allocation of household labor determines not only the effectiveness of the production response, but also the effectiveness of the consumption response. In this process, factors external to the household, such as the characteristics of the rural labor market, and factors internal to the household, such as intrahousehold decisionmaking and control of resources, can influence the outcomes.

In this chapter, the patterns of household labor allocation with adoption of new maize varieties are examined for agricultural production, other income activities, and household maintenance work. Labor allocation data were obtained between December 1985 and December 1986. During this period, the first crop cycle was completed by June, when the harvest of maize was completed. Tabulations reflecting crop labor use are therefore only made for this period. Use of nonhousehold labor in agriculture is also examined to see the extent to which the agricultural labor market influences production outcomes.

Labor Use by Crop

Among the crops, reported labor input per hectare is lowest for hybrid maize—50 percent lower than that for local maize (Table 17). As indicated earlier, only crop labor up to harvest is included in the data (that is, December through June). Obvi-

Table 17—Labor use per hectare, by crop

Crop	Number of Households	Average Area Farmed	Hours of Labor/Hectare/Season[a]		
			Family	Exchange	Hired
		(hectares)			
Maize					
Local maize					
Sole crop	115	1.2	1,269.9	34.3	10.1
Intercrop	191	1.3	1,028.3	41.2	24.6
Total	291	1.3	1,142.1	33.7	17.7
Hybrid maize					
Sole crop	57	1.8	658.6	17.6	49.5
Intercrop	34	1.5	610.5	113.1	60.6
Total	86	1.8	643.9	49.2	44.0
Total maize	301	1.8	1,128.4	34.5	39.2
Other cereals	53	0.6	1,894.6	47.2	24.4
Groundnuts and legumes	135	0.4	2,652.4	28.4	45.8
Cotton and sunflower	45	0.5	1,231.2	40.9	59.0
All crop average	308	2.08	1,558.2	38.8	42.4

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

[a]Months covered were December 1985 to June 1986.

ously, hoe cultivators use a substantially higher labor input per hectare than oxen users, controlling for type of crop, but the labor input for local maize is still twice as high whether oxen or hoes are used. These figures for labor use are comparable with Bessell's (1971) observations, made in detailed labor use investigations for Eastern Province. They are also consistent with studies of labor productivity in Zambia, which show a flattening of the yield-to-labor curve after 1,500 hours per hectare in hoe-cultivated maize (Stromgaard 1984).

One of the most striking observations of this report is that hybrid maize has a significantly lower labor input than local maize, but research on farming systems in maize production in Eastern Province indicates that hybrid maize requires 30 percent more labor than local maize for optimum yields (EPADP 1987).[25] That farmers pay much more attention to local maize than to hybrid maize is consistent with earlier observations on priority given to early planting of local maize at the start of the season. A large part of the additional labor in local maize appears to be spent in weeding. Research in Eastern Province has found that up to 25 percent of local maize fields may receive a third weeding, whereas the majority of hybrid fields are weeded only once (Eastern Province Adaptive Research and Planning Team 1984).

Groundnuts and legumes receive the highest level of labor input, with other cereals coming next. Hired labor use is highest for the cash crops, hybrid maize and cotton, followed by groundnuts. Hired labor for other cereals and local maize is much lower at only 24 and 18 hours per hectare. Exchange labor input is highest for hybrid maize and other cereals. Overall, nonhousehold labor provides an insignificant share of crop labor,

[25]Estimated labor use for hybrid maize was reported at 130 workdays compared with 100 workdays for local maize, both using oxen cultivation.

with the amount provided by exchange and hired labor nearly the same. Farmers are most likely to use hired labor rather than exchange labor on sole-cropped hybrid maize, while they are more likely to use exchange labor and rely less on hired labor for local maize, intercropped hybrid maize, and other cereals. This higher wage labor input could also be a response to the reduced input of women's labor on this crop.

Intrahousehold labor share by crop shows that women's and children's share of labor is lowest for the most commercialized crops: hybrid maize, cotton, and sunflowers (Table 18). Women's share of labor for these crops is 44 and 38 percent, respectively, while that for children is 11 and 9 percent. Women's share in sole crop local maize is 52 percent and children's share is 11 percent; in other cereals, women's is 54 percent and children's 15 percent; and, in groundnuts, women's is 53 percent and children's 12 percent. At an aggregate level for all crops and households, women provide nearly 49 percent of all household crop labor, men provide only 39 percent, and children provide 13 percent. This sample includes female-headed households, and shows the overall importance of women's farm labor in agricultural production.

Variations in Labor Use by Farm Size

In most labor-abundant and land-scarce rural areas, there is a clear pattern of lower family farm labor input with increasing incomes and farm sizes. This is largely due to greater use of wage labor and, to some extent, to a reduction in the intensity of labor input per hectare on larger farms. The pattern of labor use in smallholder agriculture where labor is scarce and land is abundant, as in this part of Zambia, is generally expected to be different. There are, however, many similarities.

Table 18— Intrahousehold labor, by crop

Crop	Number of Households	Area Farmed	Male Labor		Female		Child Labor	
			Hours	Percent	Hours	Percent	Hours	Percent
		(hectares)						
Maize								
Local maize								
Sole crop	123	1.1	312.6	36.1	454.6	52.5	98.2	11.3
Intercrop	197	1.3	319.8	39.6	372.2	46.1	115.0	14.3
Total	299	1.3	345.3	38.2	441.0	48.8	117.4	13.0
Hybrid maize								
Sole crop	58	1.7	260.1	46.4	243.7	43.5	56.6	10.1
Intercrop	35	1.5	243.2	44.4	237.1	43.3	67.2	12.3
Total	88	1.7	275.0	45.5	264.9	43.9	64.0	10.6
Total maize	307	1.8	432.7	39.6	521.3	47.7	139.5	12.0
Other cereals	60	0.5	174.2	30.9	306.5	54.4	83.1	14.7
Groundnuts	183	0.3	211.6	34.5	326.2	53.1	76.4	12.4
Cotton and sunflower	53	0.4	214.8	53.3	152.1	37.8	36.0	8.9
Miscellaneous	27	0.1	222.2	55.9	133.0	33.5	42.3	10.6
All crop average	310	2.1	703.8	39.0	874.1	48.5	225.9	12.5

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Note: Months covered were December 1985 to June 1986.

Labor use *per cultivated hectare* of land has a pattern similar to that in areas with high population density, and it declines as the area farmed increases (Table 19).[26] This is found to be so for all types of family farm labor: men, women, and children. Adult male labor on the smallest size farms (less than 1 hectare) is 734 hours per hectare, and this is reduced by 84 percent to 120 hours per hectare in the more-than-5-hectare group, about one-sixth the higher figure. The comparable reduction for women is from 1,103 hours per hectare to 134 hours per hectare (an 88 percent reduction), and, for children between 5-15 years, labor per hectare is reduced from 157 hours per hectare on the smallest farms to 31 hours in the largest—an 80 percent reduction. It should be noted that women, despite a reduction in the overall intensity of household labor input per hectare as farm size increases, still tend to put in more hours of labor on crop production than men.

Intensity of nonhousehold labor input increases with increasing farm size, especially hired labor (Table 19). Though nonhousehold labor use increases with farm size, it does not counteract the rapid reduction in labor intensity per hectare with increasing farm size.

Use of technologies such as oxen-plow cultivation is generally expected to reduce the labor requirement for farming. For the sample as a whole, this is found to be true, with farmers using oxen reporting 934 labor hours per hectare compared with 1,655 hours per hectare for hoe-using households (Table 20). But this is partly due to the larger farm size of oxen-plow cultivators. When the differences are examined for farms of similar hectarage, then the labor-saving effect of oxen cultivation is evident only for the larger farm sizes—those of more than 2 hectares. For these larger farm sizes, the reduction in women's and children's labor is most pronounced for those in the 2-to-5-hectare range.

Another question addressed in this section is how household labor allocation for all farm and off-farm activities changes with an increase in farm size. For men, the

Table 19— Total labor use, by farm size

Farm Size	N	Area	Share of Family Labor			Total Family Labor	Exchange Labor	Hired Labor	Total Labor
			Male	Female	Child				
		(hectares)		(percent)			(hours per hectare)		
Less than 1 hectare	109	0.6	37	55	8	2,121.7	14.2	8.5	2,144.5
1 - 2 hectares	89	1.5	35	51	14	1,106.9	16.5	15.4	1,138.8
2 - 3 hectares	40	2.4	45	42	13	775.5	16.7	16.6	808.8
3 - 5 hectares	47	3.7	42	44	13	526.0	18.2	17.2	561.4
More than 5 hectares	23	7.5	42	47	11	285.6	19.2	34.1	338.9
All farm average	308	2.1	38	52	10	1,273.0	16.2	14.8	1,304.0

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Note: Months covered were December 1985 to June 1986.

[26]The crop labor use tabulated in Tables 19 and 20 includes labor from December-June only. Comparisons of labor between crop and other activities use annual information.

Table 20—Total labor use by farm size and cultivation method

Farm Size	N	Area	Share of Family Labor Male	Female	Child	Total Family Labor	Exchange Labor	Hired Labor	Total Labor
		(hectares)		(percent)			(hours per hectare)		
Less than 1 hectare									
Hoe	85	0.6	36	56	8	2,128.1	13.8	7.9	2,150.0
Oxen	24	0.7	41	51	8	2,098.7	15.9	10.5	2,125.1
1 – 2 hectares									
Hoe	50	1.4	33	49	19	1,138.8	13.7	8.4	1,160.9
Oxen	39	1.6	40	54	6	1,065.9	20.2	24.3	1,110.5
2 – 3 hectares									
Hoe	17	2.3	42	45	14	944.7	15.1	11.2	971.0
Oxen	23	2.4	50	39	11	650.4	17.9	20.6	688.9
3 – 5 hectares									
Hoe	5	3.6	34	52	13	644.8	26.6	42.6	714.0
Oxen	42	3.7	44	43	13	511.9	17.2	14.2	543.2
More than 5 hectares									
Hoe	1	6.4	55	33	12	611.8	0.0	a	611.8
Oxen	22	7.6	41	48	11	270.7	20.2	35.6	326.5
All farm total									
Hoe	158	1.2	35	54	11	1,631.7	14.2	9.5	1,654.9
Oxen	150	3.0	42	49	9	895.7	18.3	20.4	934.4

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Notes: Months covered were December 1985 to June 1986.

[a]No mean value was assigned since there was only one case.

main change with larger farm size is a slight increase in agricultural work but a substantial decline in most other categories of labor use, especially in off-farm employment and business activities (Figure 2). The net result is a decrease in men's total labor per capita with larger farm size, from about 80 hours per capita per month in the lowest farm-size decile to about 50 hours per capita per month in the highest farm-size decile. The results for women's labor with respect to increasing farm size are different in that there is no decline in total labor intensity (hours per capita) in contrast to that seen for men (Figure 3). In fact, their work seems to go up in both agriculture and household maintenance activities.

These observations on labor allocation by men and women as farm work increases with farm size are consistent with observations made by Cleave (1974, 180). In his words,

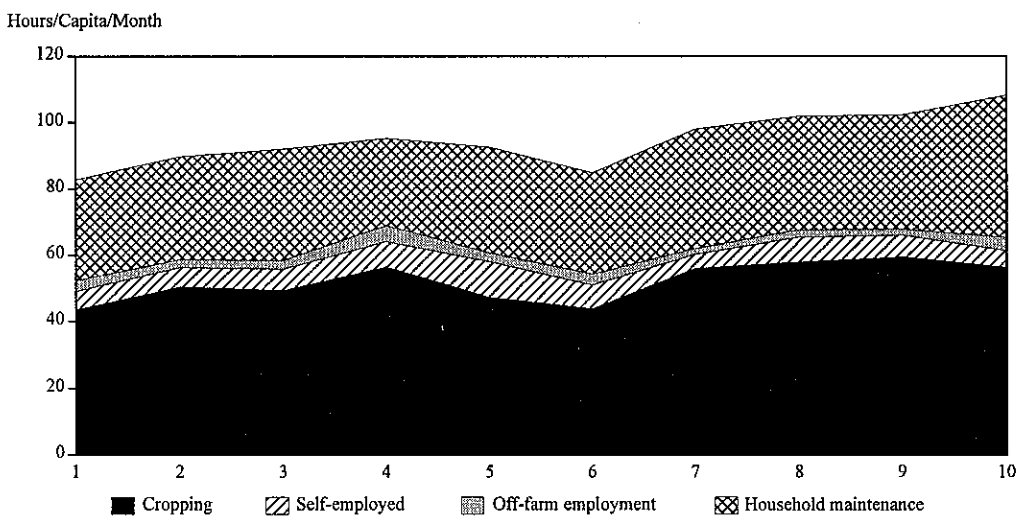
> several of these calls (nonfarm activities) on the family's time may have some economic or social value. The data available suggest, however, that, for men, at least, extra calls on time for agricultural work are drawn mainly from this collection of activities rather than from recorded resting time. For women, much of whose nonfarming time is devoted to a regular routine of domestic duties, extra work on the farm may mean less leisure.

Variations in children's work by income and farm size show that the major component of children's work is crop labor, which, on average, fluctuates between 10 and 12 hours per child per month. The second largest category of work in which children help out is in household maintenance activities. For all activities combined,

Figure 2—Average hours of labor, by activity, adult males, by deciles of total area farmed

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.
Note: The largest farms are in the tenth decile.

Figure 3—Average hours of labor, by activity, adult females, by deciles of total area farmed



Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.
Note: The largest farms are in the tenth decile.

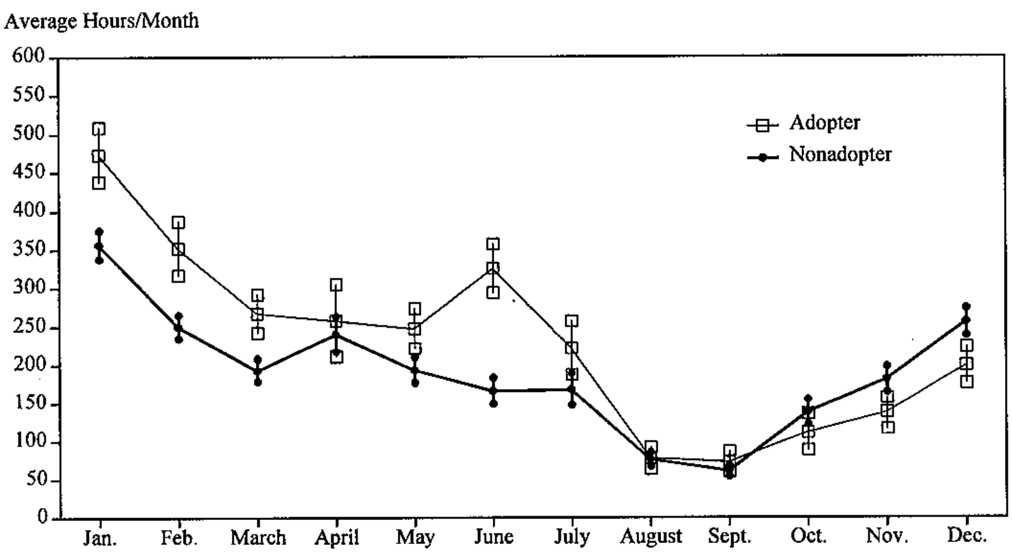
children's work averages about 15-20 hours per child per month. There is no clear pattern of any change in children's work with increasing income or farm size.

Seasonality in Crop Labor Use

Seasonal variations in labor for cropping activities largely dictate the labor allocation patterns of households. The peak labor input in agriculture is in January, with a secondary peak in June during harvesting of hybrid maize (Figure 4). Harvest of other crops is more spread out. August and September have virtually no agricultural work reported, and with the onset of rains in October or November, the cropping cycle begins again. From January, when the observations began, until the end of that cropping cycle, households that grew hybrid maize had a significantly higher household labor use in most of the cultivating months and again during harvesting. In the next crop year, the hybrid-adopting households seem to get off to a slow start. This is because they use oxen for land preparation, and early in the crop season is primarily when the labor-saving effect of this technology would occur.

As was seen earlier, the differences between adopting and nonadopting households in labor use is due to a combination of factors; for example, larger farm sizes contribute to a decrease in labor intensity per hectare, but a slightly increased intensity of labor use per person in agriculture. Oxen use, on the other hand, which is usually associated with hybrid maize adoption, brings about a reduction in labor use per hectare, if farm size is held constant. In other words, differences in seasonal

Figure 4—Average hours of family labor spent in cropping activities, by hybrid maize adoption



Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

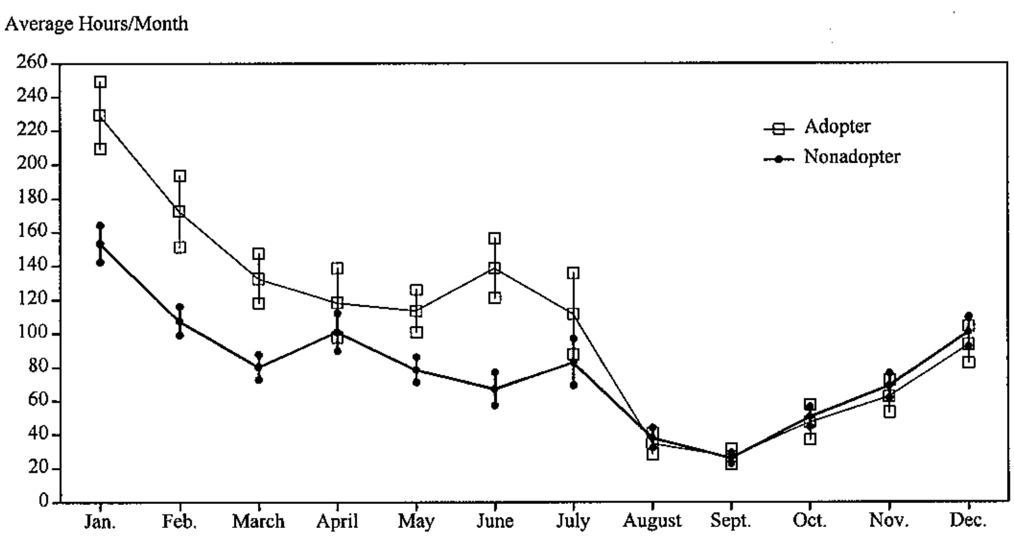
Note: The squares and dots indicate standard deviations.

patterns may reflect differences in labor use strategies. Labor strategy during harvest is an example of this. Nonadopting households have an early labor peak that extends for several months—between April and July—before tapering off in the postharvest period. Although this is partly due to an early harvest in the valley areas, it primarily reflects the much earlier beginning of harvest of local maize, as well as an extended period of harvest. The longer harvest period may be an effort to conserve labor energy following a long period of food scarcity. For hybrid-adopting households, there is a sharp peak in harvest labor in June (family labor, especially women) and in July (nonfamily labor).

The higher crop labor required in hybrid-adopting households is especially marked for males (Figure 5), and, to a smaller extent, for females (Figure 6).[27] It should be noted, however, that the absolute amount of crop labor provided by females is higher than that provided by males in both the adopting and nonadopting households. These findings are consistent with other research, which shows that with commercialization of agriculture, there is an increase in men's involvement in farming, but at the same time the demand for women's labor on crops also increases.

Seasonal variations in use of nonhousehold labor in crop production are similar to those for household labor, except that differences in season are especially pronounced for the hybrid maize adopters (Figure 7). January also has a pronounced labor peak for nonhousehold labor, similar to that for household labor. However, the

Figure 5—Average hours of male labor spent in cropping activities, by hybrid maize adoption

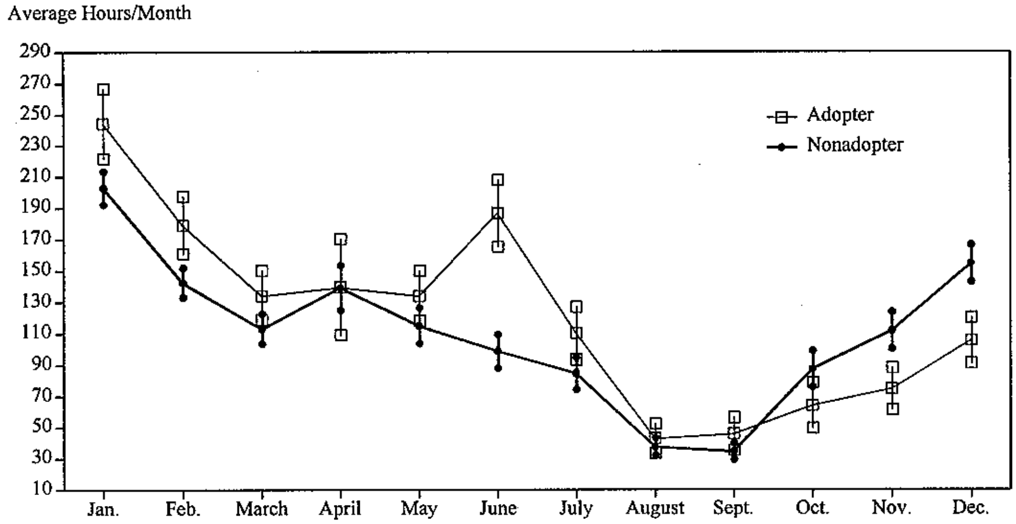


Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Note: The squares and dots indicate standard deviations.

[27]This is partly because farm size of hybrid-adopting households is larger.

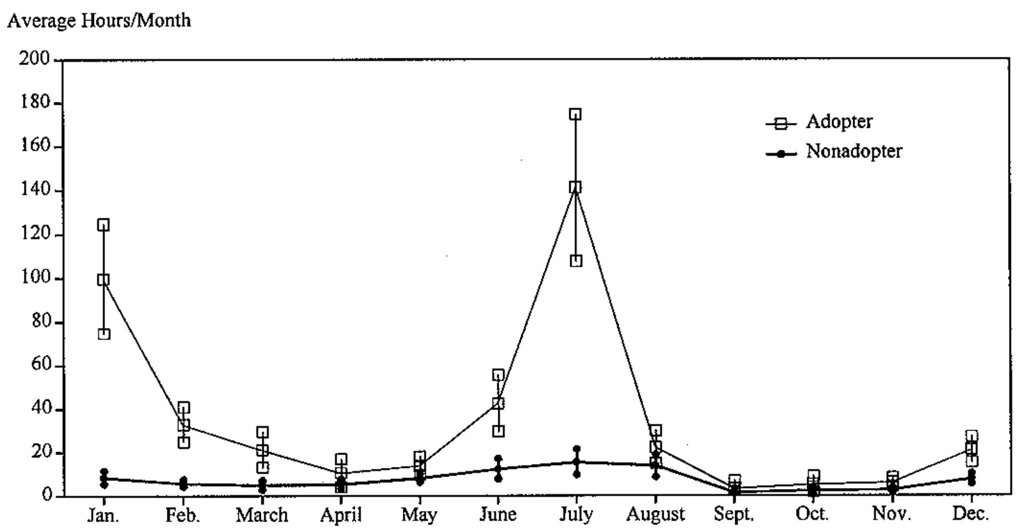
Figure 6—Average hours of female labor spent in cropping activities, by hybrid maize adoption



Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Note: The squares and dots indicate standard deviations.

Figure 7—Average hours of nonfamily labor spent in cropping activities, by hybrid maize adoption



Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Note: The squares and dots indicate standard deviations.

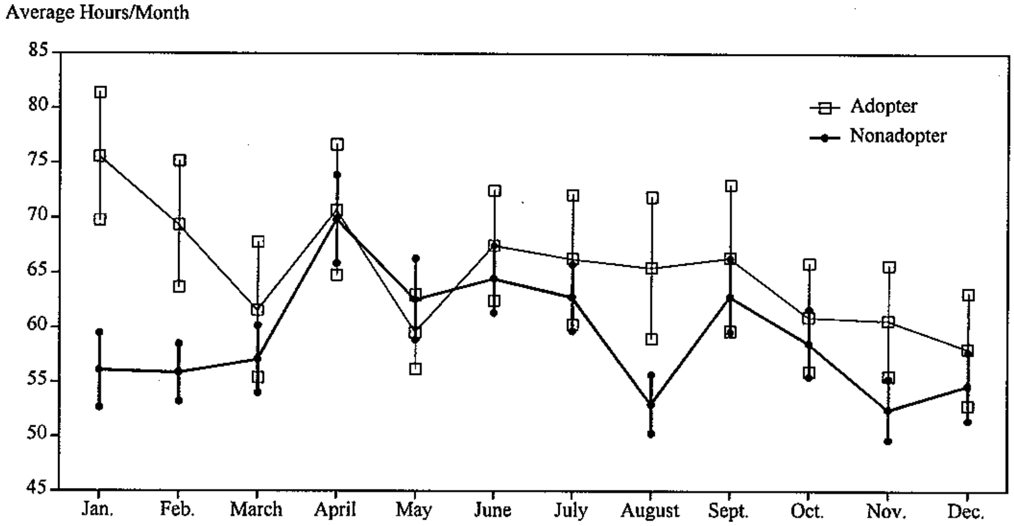
harvesting peak for nonhousehold labor comes later, in July instead of in June, suggesting that individuals supplying nonhousehold labor are more likely to finish their own harvesting before undertaking work for other households. This is in contrast to the overlapping peaks in January, which indicate that individuals providing labor at that time are facing competing labor demands for own production or wage labor, and they are opting at that time for wage labor. This is consistent with assertions made by numerous authors that food scarcity for some households during the planting/weeding season could be driving these labor choices (Kumar 1988). That nonadopters have an early rise in household crop labor could be due to the predominance of hoe cultivation in that group versus ox cultivation among the adopters. The higher labor required in land preparation and planting with hoe cultivation could explain the differences between the groups at the start of the season. During the rest of the season, however, hybrid maize adopters have a higher level of family labor use in crop production.

Labor in Household Maintenance Activities

Besides crop labor, household maintenance activities are the most time intensive, especially for women. These activities include fetching water and fuel, cutting thatch or bamboo, and other activities for house or storage repair. The seasonal pattern for these activities differs for adopting and nonadopting households. At the household level, these activities are at a seasonal high during the peak agricultural work period of January in the adopting households, while they are at a seasonally low point in the nonadopting households. After a short peak for both in April, the harvest months of June and July are also a high period for both types of households. Nonadopting households reduce this activity sharply in August, in contrast to the adopters, who maintain the previous level through September, after which the level in both tends to decrease (Figure 8).

In 11 out of the 12 months recorded, adopting households have an equal or higher level of household labor input in maintenance activities than nonadopters. The difference is statistically significant in January, February, and August. A similar observation is made about the share of women's labor in total household maintenance labor. Women from adopting households have an equal or higher share of labor in maintenance in 10 of the 12 months recorded, on average. Combining the results for both the absolute amount and the share of women's labor in household maintenance, it appears that for the adopting households, when the total amount of household maintenance labor use goes up, the women's share also goes up. This suggests that while the share of crop labor by men increases with hybrid maize adoption, their share of household maintenance activities goes down. There are three months when this does not occur: April, August, and November. In both April and August, total labor goes up, while women's share goes down. As these are the months for repairing storage bins and housing, men's traditional high involvement in these two activities is reflected here. In contrast, in November, while the total labor in these activities is stable at the previous level, women's share increases sharply, suggesting that other household members are not available to help to the extent they were before. This is consistent with the increased labor demand at this time for cropping activities. This pattern in adopting households suggests that not only is there a higher demand for

Figure 8—Average hours of family labor spent in household maintenance, by hybrid maize adoption



Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Note: The squares and dots indicate standard deviations.

labor in household maintenance activities in adopting households, but it is primarily the women who are providing it, even when demand for their labor in cropping activities is also high.

Differences in the patterns of labor allocation between males and females with adoption of improved agricultural technology are expected to be a function of factors that influence the relative profitability or returns to labor[28] and factors that influence the returns to household and individual income.[29] The net effect of each type of change on time allocation will be a function of the compensated effect of the opposing wage and income effects. These will be examined in more detail next.

Analysis of Household Labor Allocation

Farm and Nonfarm Activities

As discussed in Chapter 3, the adoption of improved agricultural technology will influence the allocation of labor in agriculture through the combined effects of changing the "virtual" wage, which includes the value of time, and increasing

[28]This is expected to lead to an increase in their returns to labor and to an increased work incentive and labor supply for agriculture.

[29]The income effect will generally decrease the supply of labor for agricultural work. This is due to increased demand for consumption time (that is, time required for household maintenance for which demand increases with income) and for leisure activities.

household income. Higher returns from adoption will shift labor away from other activities into agriculture, until the virtual wage in agriculture equates with the wage in nonfarm activities, increasing labor use in agriculture. Increments to income, at the same time, will contribute to an increased demand for time in consumption-related (and leisure) activity and put downward pressure on household labor use (supply). The optimum combination of inputs (goods and time) in the production of Z-goods (Z_i) is determined by the marginal rate of substitution between income and time,[30] which is given by the change in the virtual wage relative to the price of goods. The marginal rate of substitution is equal to the input price ratio:

$$\frac{\delta Z_i / \delta t_i}{\delta Z_i / \delta x_i} = x_i / t_i = \hat{w} / p_i , \tag{16}$$

where $\hat{w}$ is the shadow price of time, and p_i is the price of goods.

Since adoption of hybrid maize affects the productivity of labor and, hence, both the shadow price of time and household income, it will influence the allocation of labor in alternative income-generating activities (farm and nonfarm), as well as in consumption-related activities.

These two aspects of household labor allocation are analyzed here. First, the net effect of the combined change in virtual wage and income effects on labor supply in farm and nonfarm activities that occurs with the adoption of hybrid maize production is examined. Results in Chapter 5 showed that the income benefits of adoption may not be uniformly distributed across household members, and this could mean that labor supply of males and females is affected differently. The estimation equation is

$$L1_i, L2_i = f(HM^*, Ha, HM^*Ha, Ox, Educ, DI, Head, \\ Intrahh, HLabor, Dep, Ecol), \tag{17}$$

where

- $L1_i$ = family farm labor input by males and females;
- $L2_i$ = nonfarm labor input by males and females;
- HM^* = predicted hybrid maize adoption;
- Ha = total farm size;
- HM^*Ha = interaction of HM* and Ha;
- Ox = use of ox-plow;
- $Educ$ = education of head of household;
- DI = infrastructure index;
- $Head$ = sex of head of household;
- $Intrahh$ = proportion of area managed jointly or independently by female;
- $HLabor$ = household labor availability;
- Dep = dependency ratio; and
- $Ecol$ = ecological zone, plateau or valley.

[30] Z_i, as discussed in Chapter 3, denotes products such as food consumption and nutrition and health that directly contribute to the household's utility. Z_i is a combination of the commodity, market goods x_i, and time inputs, t_i.

The results suggest that patterns of labor supply do differ for males and females as the result of changes in household characteristics, including hybrid maize adoption (Table 21). On the other hand, area-level changes such as ecology and infrastructure development show a similar pattern of labor response by both sexes. Thus, while both show a similar optimization pattern with changes in exogenous variables, intrahousehold effects of household-level changes are different.

Hybrid maize adoption reduces women's labor input in both farm and nonfarm activities, when farm size is held constant, with the effect on nonfarm work being statistically significant. Since this effect is consistent for both farm and nonfarm work, it is likely to be a function of higher income together with a relative reduction in returns to women's labor with hybrid adoption. Farm size, which is closely related to household income, increases men's farm work but is neutral (insignificant) for women's. Thus, there is no evidence of a reduction in work with larger farm sizes, as is generally expected. The significant increase in agricultural work by men suggests the relative improvement in their marginal wage rate (shadow price of time) with increasing farm size.

Other household-level characteristics of interest in examining labor effects are sex of the head of household and the proportion of area managed by females. Male headship is associated with an increase in men's labor in farm and nonfarm work and a reduction in women's labor in both, compared with females who are heads of households. This seems to be primarily due to changes in the gender composition of these two types of households. An increase in the share of area managed by females has a striking effect on the reduction in women's work time in all types of activities being analyzed here. This is an interesting result; there are several reasons that will need to be researched further. The results are, however, consistent with an income effect (that is, women's income is higher when they have a larger area under their management). This has welfare implications for women and their families. The education variable has the expected positive sign for nonfarm work, indicating the higher wage rates available in the nonfarm sector with additional schooling.

The family composition variable with more adult members in a family has the expected positive sign for both men's and women's farm labor input. Nonfarm work for women also increases with the number of adult members, suggesting that larger families are associated with increased nonfarm work by women. The dependency ratio has an unexpectedly negative sign for men's farm labor. This could be an indication of additional (unrecorded) activities required of men when the proportion of children and elderly members increases. Alternatively, it could also result from the substitution of children's labor for a portion of male labor. This could not be ascertained in the present analysis.

Poor infrastructure access is associated with a higher level of labor input in agriculture by both men and women. This is consistent with an increase in the price of consumer goods relative to returns to labor in low infrastructure areas.[31] This is also equivalent to the converse of an income effect on labor supply. Women are more likely to be engaged in nonfarm activities in areas where infrastructure is poor, compared with men, which is consistent with the effect of negative income and a

[31]The policy of panterritorial pricing of agricultural products also contributes to this effect.

Table 21—Analysis of household labor allocation

Independent Variable	Mean	Total Male Labor: Farm (Mean = 1,540.6) Coefficient	t-Ratio	Nonfarm (Mean = 336.4) Coefficient	t-Ratio	Household Maintenance (Mean = 48.6) Coefficient	t-Ratio	Total Female Labor: Farm (Mean = 1,749) Coefficient	t-Ratio	Nonfarm (Mean = 823.1) Coefficient	t-Ratio	Household Maintenance (Mean = 670) Coefficient	t-Ratio
		(hours/year)						(hours/year)					
Head	0.8	470.89	2.18*	130.87	1.59	15.78	1.71	−680.17	−3.60*	−337.34	−4.75*	−263.42	−4.34*
Dep	1.1	−218.02	−2.12	−19.84	−0.50	−4.65	−0.82	−24.09	−0.27	20.28	0.60	48.13	1.28
Educ	3.8	−37.35	−1.30	23.66	2.16*	−0.70	−0.56	−20.70	−0.82	9.53	1.01	−5.19	−0.63
Hlabor	3.9	288.00	4.82*	41.82	1.83	6.15	1.32	316.03	6.04*	125.09	6.36*	178.38	5.81*
Ox	0.5	292.77	1.29	−59.45	−0.69	−4.35	−0.46	−7.79	−0.04	123.18	1.65	89.39	1.44
Ecol	0.2	−806.37	−3.36*	50.66	0.55	57.88	4.18*	−431.64	−2.05*	40.90	0.52	−134.37	−1.47
Ha	2.1	324.25	2.69*	−1.82	−0.04	...	...	35.56	0.34	12.26	0.31	...	...
DI	1.4	430.56	4.69*	−44.75	−1.27	3.65	0.94	287.72	3.57*	185.66	6.14*	163.49	6.39*
Intrahh	0.6	−237.87	−1.14	16.59	0.21	−15.60	−1.75	−801.57	−4.38*	−209.54	−3.05*	−203.90	−3.48*
HM*	0.2	81.40	0.19	−19.04	−0.11	4.89	0.38	−389.88	−1.01	−304.11	−2.10*	−146.00	−1.73
HM*Ha	1.1	−248.73	−1.84	−12.54	−0.54	...	...	6.22	0.05	59.67	1.34	...	...
HMA*	0.5	...	...	...	...	−8.64	−1.55	...	...	...	...	10.94	0.30
LogY*	4.0	...	...	...	...	−9.04	−0.34	...	...	...	...	342.90	1.99*
Constant		−432.14	−1.15	103.07	0.72	52.62	0.44	1,290.20	3.93*	300.45	2.44*	−1,318.20	−1.68
R^2 (adjusted)		0.33		0.03		0.23		0.28		0.37		0.39	
F		10.4		1.6		6.7		8.5		12.5		13.1	
Sample (N)		213		213		213		213		213		213	

Notes: The variables are defined as follows:

- Head = Sex of the household head: 1 = male, 0 = female;
- Dep = Dependency ratio: + 60 / 14–60;
- Educ = Education of the household head: grades completed;
- Hlabor = Adult equivalents per household;
- Ox = Cultivation method dummy: 1 = oxen use;
- Ecol = Valley or plateau: 1 = valley, 0 = plateau;
- Ha = Total area farmed: hectares per household;
- DI = Area level infrastructure index based on distance to 12 elements; the higher the index, the poorer the infrastructure;
- Intrahh = Proportion of area farmed by female, independently and jointly;
- HM* = Predicted hybrid maize adoption;
- HM*Ha = Predicted hybrid maize adoption (HM*) x total area farmed (Ha);
- HMA* = Predicted area under hybrid maize: hectares per household; and
- LogY* = Predicted value of household disposable income (log of per capita consumption expenditure).

*Significant at .05 level.

clustering of women in the low nonfarm wage sector. Valley sites have a significantly lower farm labor input by both males and females, holding farm size constant. The higher relative productivity of valley soils is likely to a factor in this result, combined with little opportunity for area expansion.

Household Maintenance Labor

Labor input by men and women in activities such as collection of fuel and water, food processing, home repair, and maintenance are included in this group of activities. These activities contribute to an improvement in household welfare as well as to the production of Z-goods discussed above. While the demand for Z_i increases with income, the combination of goods (x_i) and time (t_i) are a function of the relative increase in price of time relative to price of goods, as seen in the previous section. The response of household labor allocation to these activities with the adoption of hybrid maize is therefore a reflection of both changes in income and shadow price of time of household members.

The estimation equation for the labor supply to household maintenance activities is

$$T_i = f(Y^*, HM^* \; HMA^*, Ha, Ox, Educ, DI, Head, Intrahh, Hlabor, Dep, Ecol), \qquad (18)$$

where

T_i = labor input in household maintenance activities by men and women,
$log\ Y^*$ = predicted value of household disposable income,
HM^* = predicted value of hybrid maize adoption, and
HMA^* = predicted value of area under hybrid maize (other variables previously defined).

The results are presented in Table 21.

As discussed earlier, the effect of adoption of improved technologies on labor in household maintenance activities is the result of both the income and shadow price of time of household members. Income increments increase the demand for women's household maintenance labor; this effect is positive and statistically significant. This is a reflection of the labor-intensive nature of consumption-related technologies, such as pounding of maize and collection of fuel and water, which have improved little, and, finally, of the relatively lower contribution of women's productive labor to income increments.[32] As women's share of farm area increases—an indication that their share of income is also increasing—the effects on women's maintenance work are significantly negative. This is consistent with higher women's income and substitution of goods for time. These combined results indicate that, while the demand for women to spend time in household maintenance labor increases with household income gains, it can be offset if women's share of income is also maintained.

Areas with poor access to infrastructure have an effect on household maintenance time similar to a relative increase in price of goods relative to time (also shown in the

[32]This is not inherently so, but the result of women's limited access to improved production resources, technologies, training, and information.

amount of labor devoted to farm and nonfarm work discussed earlier) and a significant increase in time spent on all activities. This is especially so for women. As for men's time spent in household maintenance activities, the only explanatory variable of interest is the ecology variable, which indicates a significantly higher input by men in valley areas. The almost exclusively matrilineal ethnic background of the valley areas[33] may help explain this result. The limited adoption of hybrid maize in valley areas, which appears to rapidly raise the returns to men's agricultural labor relative to women's, is also a related factor.

The results of the examination of labor allocation to farm, nonfarm, and household maintenance activities are influenced by a mix of area, household, and intrahousehold dynamics. When farm size or income is held constant, hybrid maize adoption leads to lower labor input by women across all activities, but higher income is associated with a higher use of women's labor in household maintenance. Men's farm labor rises with farm size but is lower on farms of similar size with hybrid maize adoption.

[33]In plateau areas, there is a mix of matrilineal and patrilineal ethnic groups.

7

INTRAHOUSEHOLD DECISIONMAKING

Issues in Intrahousehold Analysis

There have been at least three interrelated rationales for the increased attention that is being paid to issues of intrahousehold access to resources and women's decisionmaking roles within their households. This set of concerns includes physical as well as human capital resources. These intrahousehold issues are relevant for policy attention on the grounds of equity, efficiency, and welfare. They have emerged roughly parallel with the larger policy emphasis on promoting the role of women in development and have been facilitated by it.

The initial concern about equity grew in direct relation to the growing body of information indicating that develoment accentuates patterns of discrimination against women where such patterns already exist, and that, in general, women are less likely to receive their share of the economic benefits generated by development (Ahmad 1980; Savane 1986; Pala-Okeyo 1988; Baser 1988; Beneria and Sen 1986). Gender-blind development is clearly not achieving gender-neutral effects.

Regarding efficiency, as evidence on the role of women in household production grew, so did the realization that if the benefits of development programs, such as improved agricultural technologies, methods, and practices, were developed and promoted without the inclusion of women from farm households as direct beneficiaries, then there would be costs in efficiency and in productivity gains (Dey 1983; Jones 1986; Burfisher and Horenstein 1985). Independent analyses have shown that the returns to providing women access to agricultural extension and training are extremely favorable, often even more so than providing the same services to men. This is especially so where traditionally women have been more involved in agricultural production than men, as in many parts of Sub-Saharan Africa (Boserup 1970; Moock 1976).

The third set of concerns addresses the welfare costs to households, children, and women when insufficient attention is paid to issues of intrahousehold resource access. These welfare losses are the most complex to document and analyze because they can derive from several sources. First, at the household level, welfare costs are a direct outcome of the efficiency losses already discussed. Welfare losses for women and children also arise from the relative changes in the value of men's and women's time arising from their differential access to development programs, resources, and technologies. It is at this point that the current debate on whether neoclassical or bargaining models better reflect household behavior becomes moot. When there is a change in the relative economic productivity of men and women in favor of men, both the neoclassical and bargaining models may predict similar outcomes in relative income shares, patterns of time allocation, and even intrahousehold food distribution.[34] However, the welfare and policy implications may be different. If the changes are a result of optimization by the household with a single utility function, as is assumed in the neoclassical model, then the case for intrahousehold policy intervention is unnecessary. However, when the same changes occur as a result of the reduced bargaining power of some individuals in the household, who in a sense "lose out," then policies also need to be designed for individuals within households.

Differences in intrahousehold utility, proposed in the bargaining models, have another possible welfare outcome that can arise if some individuals, in this case women, have a higher propensity than others to allocate income for basic household needs such as food and child care. Several studies have shown that there is a higher marginal propensity for improvements in food consumption and child nutrition to occur from increments to women's income, compared with other sources of income (Tripp 1982; Guyer 1980; Kumar 1978; Garcia 1991; Garcia and Pinstrup-Andersen 1987). However, that children are better off when women's value of time (or share of income) increases is also predicted in the neoclassical model (Becker and Lewis 1973).

In this chapter, some facets of intrahousehold decisionmaking are explored to examine the extent to which women's economic decisionmaking in agriculture and share of income are affected by household adoption of hybrid maize. Also, differences between men's and women's expenditure patterns are analyzed.

Dynamics of Women's Role in Agriculture

The precise role of women in agriculture varies widely not only geographically, but even within particular cross-sections of the population (Kumar 1987a). The context for needs, constraints, and opportunities is, therefore, relatively specific for local situations. To the extent to which the dynamics and costs of the marginalization of women can be documented in different situations, policymakers and institutions would be helped in assessing the importance of extending resources and benefits specifically to women.

Women's role in agriculture, at least in terms of their labor input, has usually increased dramatically with higher outmigration of labor from rural areas, as they take on greater responsibility for farming in de facto or de jure female-headed households (Kennedy and Rogers 1992). There is conflicting evidence on the forces that contribute to urban migration, including structural adjustment. Evidence from Zambia suggests that during the 1980s, when structural adjustment was initiated, the rate of urban population growth slowed significantly, compared with the 1970s: it declined from 5.8 percent per year to 3.7 percent per year in the 1980s. At the same time, the growth rate of the rural population increased from 1.6 percent to 2.8 percent per year, suggesting a dramatic slowdown in urban growth (Chiwele 1992).

Liberalization of agricultural prices and markets has been proceeding steadily in Zambia since the mid-1980s. This has provided increased incentives for agriculture,

[34]Differential rates of return to market activity for men and women can, for example, be traced to patterns of intrahousehold food allocation and nutrition and health outcomes that favor males over females in the neoclassical model (Rosenzweig and Schultz 1982). The bargaining model predicts similar intrahousehold allocation of welfare (Senauer, Garcia, and Jacinto 1988).

and combined with the reduction of urban food subsidies, it has improved the prospects for the rural economy in general. These changes are favorable for the rapid expansion of improved agricultural seed and fertilizer technologies (Byerlee 1992). Women's access to productive resources within this context is both more important because of the need to use the increased flow of resources to agriculture efficiently and more problematic because of the increased competition for resources due to a slowing of male labor migration to urban areas.

To summarize some relevant information presented in earlier chapters:

- Women's management of hybrid maize plots—whether independent or joint—is lower than that for other food crops (Chapter 5). This appears to be a function of the cash and credit requirements associated with input purchases for hybrid production as well as women's lower access to training and extension services (Saito 1992).
- Women's share of agricultural labor, 53 percent in households that do not cultivate hybrid maize, is reduced to 47 percent with its adoption. Even though the absolute number of person-days of agricultural work increases for women with adoption of hybrid maize, the relative share of men's labor rises faster.
- Women's labor input per hectare of hybrid maize is lower than that for other food crops. The timing of hybrid maize activities and the degree of weeding required by hybrid maize are found to be conducive to relatively low yields for this crop relative to its potential.
- The labor for household maintenance activities increases with hybrid maize adoption, and this is consistent with the income effect associated with its use.

These findings are consistent with a low involvement of women in production of hybrid maize, and, consequently, in limited access to the income improvements derived from it. This aspect will be further explored on the basis of information on intrahousehold decisionmaking that illustrates the extent of women's economic participation.

Changes in Intrahousehold Decisionmaking

This section examines characteristics of women's economic decisionmaking in Eastern Province in order to analyze how decisionmaking changes with technological change in agriculture and hybrid maize adoption. Women's contributions to household food and nonfood expenditures are analyzed as well as the following facets of women's decisionmaking role: (1) decisionmaking regarding use of improved inputs and nonhousehold labor, (2) women's access to and allocation of crop proceeds, and (3) women's contribution to household food and nonfood expenditures.

The methodology used in this part of the investigation was drawn from anthropological work on decisionmaking, in particular that used in the *Status of Women in Nepal* series of case studies synthesized by Acharya and Bennett (1981). To elicit a precise response and clarity in analysis, this methodology separates the different facets of the decisionmaking process into several actions taken by the household. It overcomes many of the subjective biases in responses to queries on decisionmaking that are characteristic of such investigations. Accordingly, questions about three facets of decisionmaking regarding use of improved inputs and hiring of nonhousehold labor were asked: Who initiated the use of the inputs? who arranged for it? and who paid for it? Regarding crop sales and access to income from sales, the queries for each crop sold were, who suggested it? who negotiated it? and how were proceeds distributed? For the allocation of income from crop sales, the query for each individual receiving income from crop sales was, what amounts were allocated to different categories of expenses? For household expenditures for each food and nonfood purchased during the previous month, the queries were, who initiated the purchase? who paid for it? and who actually went to purchase it? These questions were asked in September for the crop production and sale-related decisions (harvest was generally completed in July) and in December for the household expenditure contributions. Even though these questions were asked only once, they were designed to reflect agricultural decisionmaking and income for the previous crop cycle, and consumption expenditures at the start of the lean season.

Agricultural Decisionmaking and Income from Sales

Use of Inputs. There were 71 input decisions reported in households using hybrid maize (HM) and 68 such decisions in the nonadopting households using local maize (LM). The HM and LM terminology is used for the sake of convenience here, but in actuality both groups of households grew local maize. A significantly greater share of women participated in decisionmaking in the LM households (Table 22). Only 5 percent of input uses in HM households were suggested by women, compared with 27 percent in LM households. That women were much less involved, not even "suggesting" the use of an input, implies a perception in HM households that questions regarding new technology are men's decisions or ones that men know or can manage better.

Use of Hired Labor. Compared with the use of improved inputs in Table 22, a much larger share of decisions to hire labor were initiated and paid for by women in the HM households. This greater involvement in hiring could be largely a function of

Table 22—Percent of females making agricultural decisions

Decision Type	Number of Decisions Reported	Agricultural Decisions Made by Females: Suggested	Arranged	Paid
			(percent)	
Purchase of inputs				
Hybrid maize	71	5	8	10
Local maize	68	27	21	24
Hiring labor for				
Clearing and planting				
Hybrid maize	28	15	15	19
Local maize	34	24	29	35
Weeding and fertilizing				
Hybrid maize	50	10	10	14
Local maize	490	38	43	39
Harvesting and marketing				
Hybrid maize	50	16	12	26
Local maize	65	38	38	37

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

the labor crunch faced by women, as seen earlier. Also, women may be more knowledgeable in this area than in input purchase decisions for which they have not received any training or advice. However, women from HM households did not participate in labor-use decisions as much as women from LM households. The share of labor hire decisions by women roughly parallels the share of independently farmed land area reported in Chapter 5. In HM households, the share of land independently farmed by women was about 12 percent, compared with 31 percent in nonadopting households. The only category of labor decisions that stands out from the pattern is the high 26 percent of payments made to hired labor for harvest by women from HM households. This is consistent with the significant labor bottleneck during harvesting in adopting households discussed in Chapter 6, which appears to be more serious for women because they traditionally have a greater responsibility for harvesting than do men in this region.

Income from Crop Sales. As with decisionmaking on agricultural transactions, decisions on income from crop sales are expected to be a function of the degree of crop ownership. As mentioned earlier, even though a plot may be under the independent ownership of a man or a woman, labor input is still provided for it by other household members. While the majority of cropped land under hybrid maize was reported to be independently managed by men, women provided half or more of the labor used on this crop. Similarly, men provided labor on crops independently owned by women. The pattern of sharing income from crop sales is, therefore, analyzed in relation to the pattern of crop ownership. There is little ambiguity in the responses to this question, and no claims of a common purse or pooled income were obtained.

In looking at the share of income from crop sales received by males versus females from plots under different types of ownership, it can be seen that men receive 88 percent of the proceeds from plots under the male head's ownership and women receive 83 percent of the proceeds under the female head's ownership (Table 23). In plots owned by a male spouse (in a female-headed household), men received 91 percent of the proceeds, while women received 87 percent of the proceeds from plots

Table 23—Average amount received from crop sales by gender, by type of crop ownership, all crops combined

Principal Owner	Males: Amount Received	Males: Share of Proceeds	Females: Amount Received	Females: Share of Proceeds
	(kwacha)	(percent)	(kwacha)	(percent)
Crops owned individually				
Male-headed household				
Male owned	614	88	87	12
Female owned	30	13	206	87
Female-headed household				
Female owned	164	17	787	83
Male owned	497	91	48	9
Crops owned jointly				
Head of household and spouse	232	70	101	30

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

owned by a female spouse (in a male-headed household). These figures confirm that the concept of independent intrahousehold crop ownership/management is a valid one for this area, since this is associated with access to a large share of the crop income. In plots that are jointly owned, only 30 percent of the proceeds went to women and 70 percent to men. Since the bulk of plots under women's ownership are in the joint ownership category, this division of crop income probably represents a large part of their income from crop sales.

Data on sharing income from sale of crops suggest that the premium is on management decisions and not on provision of labor and that management decisions parallel the extent of crop ownership. Therefore, a decline in the share of the crop owned by women will directly translate to a reduced share of income. Assuming that the overall pattern of crop ownership could be translated into income shares along the lines of the cash income shares, then women's income share is calculated to decline from 40 percent in nonadopting households to 23 percent in adopting households. The absolute amounts of women's income are, however, likely to be higher with adoption, since it is also associated with larger farm sizes.

Intrahousehold Expenditure Patterns

Allocation of Income from Crop Sales. As mentioned earlier, income allocation decisions from crop sales were documented in September, two-to-three months after harvest. Since cash sales are lump sum receipts, their allocation is likely to be different from allocation of periodic expenses. Only expenditures made up to the date of the interview were thus captured, and amounts saved for later use were not reflected in the numbers reported.

In terms of the frequency with which men and women spend on different items, women spend most often on food items for the household, followed by personal items, primarily clothing (Table 24). Men, on the other hand, are likely to spend most often on repayment of agricultural loans and second on social expenses. The actual amount of expenditure incurred by men each time is almost always higher than that

Table 24—Frequency of spending from proceeds of crop sales on various items, by sex

Expenditure Item	Males			Females			Total	
	(kwacha)	(N)	(percent)	(kwacha)	(N)	(percent)	(N)	(percent)
Household dietary item	27.05	56	46.7	21.03	64	53.3	120	100.0
Food outside of home	30.04	52	57.8	8.33	38	42.2	90	100.0
Social expenditure (including alcohol)	13.49	71	78.0	3.95	20	22.0	91	100.0
Gift	50.49	34	52.3	90.25	31	47.7	65	100.0
Personal item	79.55	116	47.2	70.63	130	52.8	246	100.0
Repayment of loan	404.07	26	83.9	71.80	5	16.1	31	100.0
Other	158.05	35	58.3	54.02	25	41.7	60	100.0
All items	...	157	49.4	...	161	50.6	318	100.0

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Note: N is the number of expenditures.

spent by women, with the greatest difference in the case of loan repayments, foods consumed outside the home, and social expenses. The only item on which women spend more than men is gifts. It is possible that gift giving is a way for women to pay for or derive services from their relatives and friends, and that they depend on this network more than men do.

When average household expenditures from proceeds of crop sales are examined (in the months immediately following the harvest period), the biggest item for men is repayment of loans followed by personal items. For women, personal items is the most important expenditure group. The average amount of expenditures made by women on all items combined is about half that of men (Table 25). However, if loan repayments are removed, then the differences are reduced substantially.

Household Consumption Expenditures. The pattern of intrahousehold expenditures from the proceeds of crop sales in the postharvest period reflects expenditures at that point in time. Intrahousehold consumption expenditures were obtained in December, at the start of the lean season. For each expenditure item, information was collected on who initiated the expenditure, who paid for it, and who actually went to purchase it.

Food items accounted for 21 percent and nonfood items for 79 percent of the total cash expenditure budget for the month. Men made up 80 percent and women 20 percent of the monthly expenditures. In the men's budget, food items accounted for 19 percent and nonfood items for 81 percent. Women, on the other hand, spent 28 percent for food and 72 percent for nonfood (out of which maize milling was a major item). Since women had a higher propensity to spend on food, their share of food expenditures was nearly 30 percent. These figures show that even though the major share of both food and nonfood cash expenditures were made by men, virtually all of women's expenses were either for food or food processing.

In order to examine changes in intrahousehold decisionmaking with hybrid maize adoption, the three facets of decisionmaking for food expenditures were examined (Table 26). Women were most likely to initiate purchases of green leafy vegetables, meals consumed outside the household, fats, oils, beans, and groundnuts. All of these are items that women have the primary responsibility to provide. Women spend large amounts of time collecting and drying leafy vegetables from the wild and from fields; expenditures on this item largely reflect their concern for its provision in the diet.

Table 25—Mean expenditure from the proceeds of crop sales, by sex

Expenditure Item	Males	Females
	(kwacha)	
Household dietary item	9.65	8.31
Foods outside of home	9.95	1.95
Social expenditure (including alcohol)	6.10	0.49
Gift	10.93	17.27
Personal item	58.78	56.68
Repayment of loan	66.92	2.22
Other	35.23	8.34
Total expenditure	197.56	95.25

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Table 26—Percent of food expenditure decisions made by females in households growing hybrid versus local maize

Food	Percent of Food Expenditure Decisions by Females		
	Initiated	Paid	Purchased
Cereals			
Hybrid maize households	40	27	41
Local maize households	50	33	58
Beans and nuts			
Hybrid maize households	60	54	70
Local maize households	62	34	61
Leafy vegetables			
Hybrid maize households	91	61	88
Local maize households	86	62	93
Meat and fish			
Hybrid maize households	42	32	52
Local maize households	55	35	59
Milk and products			
Hybrid maize households	42	42	42
Local maize households	43	57	60
Fats and oils			
Hybrid maize households	67	46	54
Local maize households	84	41	64
Sugar			
Hybrid maize households	36	31	38
Local maize households	59	40	52
Meals outside of home			
Hybrid maize households	75	52	65
Local maize households	80	50	64

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Similarly, groundnuts and beans are the traditional relish items provided by women, and fats and oils are also essential in the diet. Since provision of meals is the woman's responsibility, it is not surprising that she often initiates an expenditure on a meal consumed outside the home. In most cases (except milk and milk products), women may initiate the expenditure, but men are more likely to actually pay for it.

For these foods—those for which women are most likely to initiate an expenditure—their ability to actually incur an expenditure is either the same or better in hybrid maize households. In contrast, in the case of food items for which women are less likely to initiate an expenditure, such as cereals, meat and fish, sugar, and milk products, women in hybrid maize households are less likely to incur an expenditure. It is possible that women expect men to take care of expenditures for items for which women generally do not feel responsible. This reduction in women's willingness to incur expenses is plausible, given that their income share is reduced in hybrid maize households, even though their absolute level of income may increase with adoption of hybrid maize.

Summary

The study of intrahousehold decisionmaking shows that women are less likely to take on economic transactions for agricultural production in hybrid maize-adopting households. In all households, they are more easily involved in labor hire decisions than in input use decisions, which is probably a direct reflection of their lack of access to extension services. Access to income from crop sales within the household is clearly indicated as a function of the crop ownership pattern, with the primary owners receiving the bulk of proceeds. Where men and women jointly own the crop, women receive only 30 percent of income from sales. This figure is more likely to reflect the extent of women's management decisions than their labor input. To what extent a bargaining process was involved in this division of proceeds could not be identified, but it is likely. Intrahousehold expenditure patterns confirm that women's expenses are virtually all for either purchases of food or for maize milling, indicating a high propensity for food-related expenditures. The pattern shows that in most instances, women in hybrid maize-adopting households are less likely to initiate food purchases than those in nonadoptive households, which could mean that their bargaining power is lower. In terms of actually paying for food items, women's share of expenses in hybrid maize-adopting households is more likely to decrease or stay the same.

8

FOOD CONSUMPTION AND NUTRIENT INTAKES

Issues and Consequences of Technological Change in Agriculture

This chapter examines the patterns and distribution of food consumption and nutrient intakes in Eastern Province and the effects of technological change in agriculture on them. Growth in agricultural production and technological change in agriculture influence dietary intakes in many ways. At the local level, the main economic effects are through the improvement in returns to land and labor, including the direct price and income effects and the indirect effects on agricultural incomes of farm-nonfarm employment linkages (Pinstrup-Andersen 1979; Mellor and Lele 1973).

Several studies have shown that the level of food consumption improves with technological change and commercialization of agriculture for households that participate in these changes (Kennedy 1989; von Braun, Puetz, and Webb 1989; von Braun, Hotchkiss, and Immink 1989; Bouis and Haddad 1990). The results of the subset of studies carried out in Sub-Saharan Africa are similar in this respect to those found in other parts of the world. But the literature also recognizes the potential of new technology to exacerbate income inequalities between households (Lipton and Longhurst 1989). Analysis of the effects on those not participating in the adoption of changing agricultural practices is more difficult and the results are less clear-cut (Binswanger and von Braun 1991). Income inequality has increased between geographical areas, between early and late adopters of new technology, and within households. It is important to note that when these effects have occurred, they are generally not due to the nature of the technology itself but to the underlying inequity in distribution of resources prior to adoption (Pinstrup-Andersen 1979). Agricultural research and policies geared to promote the spread of new technologies can, however, have a favorable impact on the distribution of benefits, provided that awareness of the costs to society and economic growth are incorporated into the decisionmaking process.

Dietary benefits can occur through income and employment growth and through changes in intrahousehold income. Not only are different households affected in different ways, but members of a household are also affected differently by marginal improvements in returns to land and labor with technological change. The extent of dietary improvement is generally greater when the inadequacies are greater, that is, when the beneficiaries are among the lower income groups.

Marginal increments to caloric intake at very low income levels are expected to occur rapidly and primarily through an increase in cereal consumption. Since cereals are generally the least expensive calorie source, they predominate at the lowest income levels. As incomes increase, foods with high income elasticity that played a very small part in the diet before contribute an increasing share of calories. As this process continues, household diets tend to move toward what is considered the cultural norm or "ideal" diet.[35] In general, this is desirable because the ideal diets in most societies are nutritionally adequate for meeting *average* requirements, but this does not necessarily mean that all individuals within a household will be adequately nourished if nutrients are not equitably distributed. As incomes increase, not only is the share of calories from high income-elasticity foods higher, but the number of food items in the diet also increases. This contributes to greater diet diversity, which has long been considered desirable from the standpoint of ensuring adequate access to the full range of nutrients required by the body.[36]

More recently, attention has shifted to how intrahousehold utility functions and income control affect allocation of household resources and outcomes, such as food consumption levels. Both economic theory and empirical observations have generally shown that increasing women's share of income (the value of women's time) results in a higher marginal utility for household food consumption and other investment in the quality of human capital than income from other sources (Senauer, Garcia, and Jacinto 1988; Duncan 1992). What has been unclear is whether these allocations arise from a single household utility function or are the result of intrahousehold bargaining. Anthropological research in several rural societies, including some in Sub-Saharan Africa, has questioned the concept of pooled household income, finding that women have a separate purse and different expenditure patterns from men. The present study verifies that this pattern also exists in Eastern Province, Zambia.

Analysis of the dietary effects of technological change is made more problematic when the main source of income and consumption is own-farm production. This problem of simultaneity is even greater where labor is scarce, as in Eastern Province. In these situations, seasonal food availability can be a factor in labor allocation decisions and in agricultural productivity (Kumar 1988). To the extent that food consumption becomes a factor in income generation, the measured income will not be exogenous, and the association is therefore more complex. This factor will be taken into consideration in the multivariate analysis presented later in this chapter.

Overall Diet and Nutrient Intake Levels in Eastern Province

Estimates of food consumption were obtained through a modified food expenditure record, to which adjustment was made for amounts actually consumed during the previous week. Since estimates were based on food recall, some approximations were

[35]In a closed traditional society, it is relatively easy to determine the "ideal" diet. However, as markets, new products, and advertising (or some of the more effective forms of nutrition education) come into the picture, they produce new versions of the ideal. These factors, while most predominant in urban situations, may also appear in some rural situations.

[36]The early use of Guttman scales in the 1960s was in acknowledgment of this need for diet diversity (Sanjur and Romero 1975). Studies using the Guttman scale found this indicator to be highly associated with child nutrition.

involved, but these were minimized by interviewing only the primary person in charge of food preparation and obtaining quantities in local units, which were subsequently standardized. The main advantage of obtaining a seven-day record is that a better dietary profile is obtained, including foods consumed infrequently. Studies have shown that food consumption estimates from 24-hour recall give lower figures for intakes compared with other methods (Black et al. 1991). This was particularly pronounced for higher-income groups in a study comparing 24-hour recall and food expenditure methods (Bouis and Haddad 1990). Another recent study found the extent of underreporting in 24-hour records to be about 18 percent (Mertz et al. 1991), whereas recording recent expenditures alone tends to overestimate consumption for households that make bulk purchases (likely to be the wealthier ones).

Maize is the main staple food in the average diet in Eastern Province. It contributes about 483 grams per capita per day out of a total cereal content of 518 grams (Table 27). The maize consumed is predominantly out of local or household consumption, with only 21 grams of it being purchased in the form of breakfast or roller meal.[37] Sorghum makes a slightly larger contribution to the diet than finger millet, rice, or wheat. Overall, cereals contribute about 80 percent of calories in the average diet. A comparison of the results of this survey with estimates from the 1970s shows an increase in nearly all cereals in the diet, with the exception of finger millet, which seems to have declined substantially (FAO 1976).

The average consumption picture culled from the survey shows a diverse and fairly well balanced diet, with vegetable protein-rich foods providing about 45 grams (on a dry weight basis) and animal foods providing about 60 grams (on a fresh weight basis) of the daily diet. Vegetables and fruits constitute about 245 grams (on a fresh weight basis) per day, and sweet potatoes, about 39 grams. Improvement of the diet may require less dependence on cereals and a higher content of protein-rich foods and fats and oils than currently available, especially in diets of children. Since both of these food groups are expected to have a high income elasticity, income improvements should improve the average diets consumed. If the comparison with consumption figures from the 1970s is indicative of changes taking place, there does not appear to be a clear-cut improvement. From the 1970s to 1986, the consumption of cereals, legumes, and milk increased, while consumption of meat and fish and fats and oils declined.

The average nutrient intake picture also looks relatively good, with the average caloric and protein intake sufficient to meet the needs of the population. The per capita caloric intake is 2,319 calories per day, with about 66 grams of protein consumed (Table 28). Intakes of calcium, iron, and the B vitamins (thiamine, riboflavin, and niacin) are adequate to marginally low. Although vitamin A content was not calculated due to large gaps in the food composition tables for many vitamin A-rich foods in the Zambian diet, the large amount of sweet potatoes, pumpkin, and leafy vegetables in the diet indicates a good supply of this vitamin.

About 73 percent of calories are derived from carbohydrates. Proteins contribute 11.3 percent of calories, which is at the low end of the satisfactory range. Fats

[37]Roller and breakfast meals are two forms in which maize meal is marketed in Zambia. Roller meal has an extraction rate of about 90 percent, while breakfast meal has a 65 percent extraction rate.

Table 27—Annual average of daily per capita consumption of calories, by food groups, Eastern Province

Food Item	Per Capita Calorie Consumption: Annual Average	Per Capita Calorie Consumption: Standard Deviation
	(grams)	
Cereals		
Breakfast and roller meal[a]	20.48	72.01
Maize	462.44	266.70
Sorghum flour	16.41	49.30
Finger millet flour	5.01	22.23
Rice	7.61	25.58
Wheat flour	6.17	18.32
Legumes		
Fresh beans and peas	4.97	9.07
Dried beans and peas	13.03	13.55
Fresh groundnuts and groundpeas	11.13	14.09
Dried groundnuts and groundpeas	27.70	32.23
Roots		
Sweet potatoes	38.91	49.52
Fresh cassava	5.21	12.29
Dried cassava	0.26	1.60
Roots, miscellaneous	1.38	4.29
Fresh vegetables and fruits		
Pumpkins and gourds	125.75	141.69
Fresh leafy vegetables, cultivated	42.76	29.98
Fresh leafy vegetables, collected	7.33	9.20
Other fresh vegetables	17.83	16.41
Fruits, wild	0.40	4.76
Fruits, cultivated	34.73	61.99
Dried vegetables		
Dried leafy vegetables, cultivated	2.45	4.57
Dried leafy vegetables, collected	0.39	0.87
Other dry vegetables	0.31	0.79
Fresh meat		
Fresh meat, wild	3.87	19.01
Fresh meat, reared	20.30	29.72
Poultry, wild	0.26	2.03
Poultry, reared	4.87	6.70
Fresh fish	2.78	5.87
Dried meat, fish		
Dried meat, wild	0.93	2.58
Dried meat, reared	0.49	1.81
Dried fish	1.23	2.90
Miscellaneous		
Organ meats	0.92	2.63
Eggs	0.57	1.23
Dried caterpillar	0.09	0.29
Termites	0.13	0.34
Others		
Fresh milk	10.56	31.34
Other milk products	0.08	0.42
Fats and oils	1.84	3.67
Sugar	9.94	13.97
Other foods	25.71	34.37
Alcoholic beverages	143.98	223.35

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

aThese are two forms of purchased maize meal.

Table 28—Annual average of daily per capita consumption of nutrients, Eastern Province

Nutrient	Average Daily per Capita Consumption	Standard Deviation
Energy (calories)	2,319.36	202.39
Protein (grams)	65.51	5.61
Fat (grams)	35.12	3.76
Carbohydrates (grams)	423.01	36.02
Calcium (milligrams)	445.93	37.87
Iron (milligrams)	22.39	1.72
Thiamine (milligrams)	1.05	0.10
Riboflavin (milligrams)	1.03	0.09
Niacin (milligrams)	14.01	1.45

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

contribute only 13.6 percent, which is low compared with the common dietary recommendation of about 20 percent of calories from fat for a normal population.

While the average consumption picture for the year gives some useful pointers on the diet pattern in the area, it is of limited usefulness because of variations between households, individuals in households, and seasonal consumption patterns. Some indication of this variation can be seen in the high variances of the annual consumption averages in Tables 27 and 28. Although individual consumption data were not obtained for this study, some of the other dimensions of variations in food intake in the area are examined in the next section.

Variations in Dietary Intakes by Ecology and Area-level Technological Change

The two types of area-level variations in food consumption examined here are, first, ecology or variations in natural resource endowments and, second, spread of hybrid maize adoption. Within Eastern Province, there are two main ecological areas: the plateau, where the majority of the population resides, which is better developed infrastructurally, and the Luangwa Valley, which has good agricultural soils but lower rainfall. The valley is heavily infested with the tsetse fly, carrier of the deadly cattle disease, trypanosomiasis, which effectively eliminates oxen plowing. As a result, farm sizes are much smaller in the valley, and hybrid maize adoption is virtually absent. In addition to comparing consumption patterns in the plateau and the valley, consumption at plateau sites that have a high degree of hybrid maize adoption was compared with that at plateau sites with little adoption.

The main differences in the diets of the two ecological areas were found to be in cereal composition and a higher intake of fish and wild meats in the valley. Households in the valley had a higher content of sorghum, finger millet, and rice in their diets, as well as a higher content of purchased maize meal. In order to examine the pattern of cereal intake at the different sites in greater detail, the households were further categorized by size into small and large farms, based on the median per capita farm size for those areas. For example, households with more than 0.171 hectares per capita in the valley were categorized as large, those in the low-adoption plateau areas with more than 0.294 hectares per capita were categorized as large, and, in the high-adoption plateau areas, households with more than 0.420 hectares per capita were categorized as large. Both valley and low-adoption plateau areas have a higher degree of dependence on purchased maize meal than plateau areas with higher adoption rates. This clearly indicates that more maize is available in high-adoption areas (Table 29).

Overall grain consumption is lowest among the small farmers in the valley areas and highest among the large farmers in the high-adoption plateau areas. These differences parallel the differences in farm sizes between the valley, low-adoption plateau, and high-adoption plateau areas.

The differences in the annual average intake levels for the major nutrients, as shown in Table 30, do not follow as clear-cut a pattern as the differences in quantity of total cereal consumption. Valley areas tend to come out better than low-adoption plateau areas in intakes of many nutrients that are indicators of diet quality, for example, protein, calcium, and iron. The intake of calories and dietary components that contribute to it, such as carbohydrates and fat, parallel the earlier observed differences in farm size between the three areas. The most striking difference is that the plateau sites have nearly twice as much fat content in their diets, whereas valley

Table 29—Daily per capita consumption of cereals, by farm size, in valley and plateau regions and high and low adoption areas

	Region				Plateau			
	Plateau		Valley		High Adoption		Low Adoption	
Cereals	Small Farms	Large Farms	Small Farms	Large Farms	Small Farms	Large Farms	Small Farms	Large Farms
	(grams)							
Breakfast and roller meal[a]	18	11	23	26	5	8	44	16
	(64.9)	(28.0)	(44.8)	(36.8)	(17.5)	(27.8)	(104.5)	(28.1)
Maize	453	584	244	302	489	633	383	488
	(222.9)	(295.6)	(71.9)	(133.8)	(238.5)	(320.3)	(171.0)	(212.3)
Sorghum flour	...	...	45	118	...	...	...	...
			(50.5)	(92.2)				
Finger millet flour	1	...	28	20	1	...	...	...
	(5.8)		(39.5)	(49.2)	(7.1)			
Rice	2	2	40	23	2	2	1	...
	(4.6)	(4.0)	(52.6)	(47.3)	(5.5)	(4.8)	(1.7)	
Wheat flour	6	6		1	4	7	10	6
	(12.4)	(12.1)	...	(2.5)	(7.2)	(12.3)	(18.3)	(11.9)

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Note: Numbers in parentheses are standard deviations. The ellipses (. . .) indicate a nil or negligible amount.

[a]These are two forms of purchased maize meal.

Table 30—Annual average of daily per capita nutrient intakes, by valley and plateau regions

Nutrient	Plateau	Valley	Plateau Adoption Areas High	Plateau Adoption Areas Low
Energy (calories)	2,367.28	1,819.60	2,491.65	1,908.78
	(221.86)	(168.19)	(339.26)	(83.71)
Protein (grams)	66.43	55.94	69.93	52.50
	(6.20)	(4.35)	(8.79)	(1.45)
Fat (grams)	36.81	17.50	39.14	25.55
	(4.20)	(1.23)	(3.13)	(1.76)
Carbohydrates (grams)	429.48	355.48	446.23	358.38
	(39.58)	(37.71)	(68.36)	(16.74)
Calcium (milligrams)	436.32	546.23	423.57	350.75
	(44.14)	(78.25)	(51.04)	(56.19)
Iron (milligrams)	21.09	35.87	21.42	16.85
	(2.03)	(9.65)	(2.66)	(1.20)
Thiamine (milligrams)	1.06	0.88	1.04	0.82
	(0.12)	(0.05)	(0.10)	(0.16)
Riboflavin (milligrams)	1.06	0.69	1.06	0.93
	(0.09)	(0.04)	(0.14)	(0.06)
Niacin (milligrams)	14.18	12.26	14.87	9.70
	(1.68)	(0.33)	(1.62)	(1.03)

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Notes: Numbers in parentheses are standard deviations. Adoption of hybrid maize was negligible in the valley areas.

households consume more iron and calcium, largely because of the higher sorghum and finger millet content of their diets.[38]

A comparison of the plateau sites by degree of hybrid maize adoption shows that low-adoption plateau areas had a lower level of consumption than the high-adoption areas. This difference was found across the board for all the nutrients, since the composition of the diet on all plateau sites was essentially the same (in contrast with the differences between the plateau and the valley diets).

To address the issue of diet diversity, a simple count of the number of food types consumed in the past week was recorded during each monthly visit and compared for the different areas (Table 31). (The total number of possible food types is listed in Table 27.) The annual food count represents the total number of food types present in the aggregated diet for the 12 months. During the lean months (January-February), the diet was more diverse in the low-adoption plateau areas than in the high-adoption areas, and this is attributed to greater diversity in both own-produced and purchased foods. A larger number of food items are purchased in the low-adoption plateau areas than in either the high-adoption plateau areas or in the valley areas. The diversity of

[38]Sorghum has 2.5 times the calcium and 3 times as much iron as maize, and finger millet has more than 30 times the calcium and more than 3 times as much iron as maize. Maize, however, has higher carotene content. Most of these nutrients are present in the pericarp (bran and germ) of the grain and may be biologically unavailable for absorption by the body in varying degrees, depending on the type of processing and cooking used.

Table 31—Food diversity, by month, region, and level of adoption of hybrid maize

	Plateau, Low Adoption Areas			Plateau, High-Adoption Areas			Valley, Low-Adoption Areas		
		Own			Own			Own	
Month	Total	Produced	Purchased	Total	Produced	Purchased	Total	Produced	Purchased
January	6.56*	5.02*	1.86*	5.27	4.30	1.22	6.58	5.35	1.63
February	6.98*	5.14	2.18*,**	6.16	4.95	1.57	7.16	6.20**	1.48
March	6.97	5.22	1.96**	6.93	5.67	1.63	6.73	6.14**	0.79
April	7.33	5.69	2.02**	7.62	6.21	1.70	7.89	7.43**	0.68
May	8.18**	5.96	2.62*,**	7.62	6.36	1.57	7.22	6.63**	0.75
June	8.43	6.13	2.81*,**	8.05	6.35	2.13	7.69	6.70	1.39
July	8.77**	5.85	3.43*,**	8.34	6.66*	2.04	7.59	6.24	1.84
August	8.15	5.20	3.42**	7.76	5.70	2.49	7.59	5.71	2.63
September	7.83**	5.23**	3.09**	7.91	5.80	2.56	6.32	4.47	2.34
October	7.63**	5.16	3.13**	8.20	5.89*	2.90	6.47	4.95	2.21
November	7.18**	4.88	2.89**	7.48	5.46*	2.53	5.89	4.41	1.86
December	7.46**	5.83**	2.61**	7.44	5.52	2.40	5.86	4.53	1.56
Annual	15.64	11.41	7.93*,**	15.94	13.18*	6.05	18.56**	15.83**	6.32

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Notes: The measure of food diversity is derived by counting the number of food categories out of a total of 42 possible categories that were present in the diet during the period of the survey. One week's diet was recorded each month and the results are based on that. Adoption of hybrid maize was negligible in the valley areas.

*Significantly higher at 0.05 level, comparing plateau low- and high-adopting areas.

**Significantly higher at 0.05 level, comparing plateau low-adopting areas and valley areas.

own-produced food items in the diet is greatest in the valley areas, and this is a reflection of a more diversified production system and greater access to foods from fishing, hunting, and collecting from the wild in these areas.

An examination of the geographical variation of diet in the valley and the low- and high-adoption areas of the plateau indicates that caloric intakes are best in the plateau areas with high adoption of hybrid maize, but that this also parallels the variations in farm size in the three areas. Indicators of diet quality, such as protein, calcium, and iron, and aggregate measures of diet diversity, however, suggest that low-adoption valley and plateau areas do better. This is due to a combination of factors that will be analyzed in the multivariate analysis.

Dietary Intake Variations by Household Level

In contrast to the earlier comparisons of hybrid maize adoption at the area level, when consumption is compared according to hybrid maize adoption at the household level, there are no clear-cut improvements evident. While the primary food components—calories, proteins, carbohydrates, and fats—are slightly higher for the year in the hybrid maize-adopting households, the micronutrients analyzed are all slightly higher in the nonadopting households (Table 32). These observations suggest that

Table 32—Mean daily per capita nutrient intake, by household use of hybrid maize

Nutrient	Nutrient Intake: Nonadopters of Hybrid Maize	Nutrient Intake: Adopters of Hybrid maize
Energy (calories)	2,148.94	2,263.13
	(1,057.30)	(1,001.15)
Protein (grams)	61.53	63.44
	(29.15)	(26.99)
Fat (grams)	29.21	34.87*
	(20.61)	(21.73)
Carbohydrates (grams)	399.06	406.68
	(193.22)	(184.37)
Calcium (milligrams)	451.59*	367.17
	(265.36)	(167.14)
Iron (milligrams)	23.82*	19.54
	(17.03)	(8.67)
Thiamine (milligrams)	0.97	0.91
	(0.56)	(0.48)
Riboflavin (milligrams)	0.95	0.95
	(0.55)	(0.43)
Niacin (milligrams)	13.03	12.89
	(7.68)	(7.09)

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Note: Numbers in parentheses are standard deviations.

*Significantly higher at the .05 level.

nonadopters in areas with a high degree of hybrid maize adoption are better off than nonadopters in other areas. While this finding is consistent with the overall larger farm sizes in the high adoption areas, it could also be the combined result of improved returns to labor and improved food availability at the local level.

In order to examine the differences at the household level by hybrid maize adoption, households are subdivided by farm size. Results show that small-farm adopters have better diets than small-farm nonadopters, but large-farm adopters' diets are not better than large-farm nonadopters' (Table 33). In fact, except for fat consumption, which is higher among large farms that are adopters of hybrid maize, all other diet constituents examined show that the large farms that have not adopted hybrid maize actually have a higher level of nutrient consumption. The results suggest that income elasticities of food consumption may be much lower for hybrid maize adopters, compared with nonadopter households. These findings are consistent with earlier results, which showed that hybrid maize adoption had a significantly positive impact on household consumption expenditure, but this was not as evident for larger farms.

To examine further the changes in the pattern of food consumption that occur with hybrid maize adoption on small and large farms, the annual average intakes of the main food groups are tabulated (Table 34). The main household dietary components that are higher among small-farm adopters are cereals (up 11 percent), milk

Table 33—Mean daily per capita nutrient intake, by hybrid maize adoption and farm size

	Nutrient Intake			
	Nonadopters of Hybrid Maize		Adopters of Hybrid Maize	
Nutrient	Small Farms	Large Farms	Small	Large Farms
Energy (calories)	1,923.90	2,461.50*	2,165.53	2,306.01
	(993.47)	(1,069.08)	(837.63)	(1,068.23)
Protein (grams)	54.30	71.57*	59.48	65.18
	(26.86)	(29.37)	(22.32)	(28.78)
Fat (grams)	27.29	31.88	32.98	35.70
	(21.36)	(19.33)	(22.04)	(21.71)
Carbohydrates (grams)	353.91	461.76*	389.86	414.02
	(176.15)	(199.26)	(141.46)	(200.90)
Calcium (milligrams)	376.16	556.37*	360.40	370.14**
	(218.14)	(289.70)	(172.01)	(166.21)
Iron (milligrams)	20.72	28.12*	19.44	19.59**
	(14.83)	(18.94)	(9.57)	(8.33)
Thiamine (milligrams)	0.83	1.17*	0.88	0.92**
	(0.54)	(0.54)	(0.46)	(0.50)
Riboflavin (milligrams)	0.83	1.10*	0.92	0.96
	(0.50)	(0.57)	(0.34)	(0.47)
Niacin (milligrams)	11.72	14.85*	12.83	12.91
	(8.06)	(6.74)	(7.02)	(7.18)

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Note: Numbers in parentheses are standard deviations.

*Significant at the .05 level, comparing small and large farm size groups.

**Significant at the .05 level, comparing nonhybrid maize producers and hybrid maize producers.

(up 180 percent), alcoholic drinks (up 71 percent),[39] groundnuts (up 18 percent), and pumpkin and gourds (up 23 percent). For the large-farm adopters, quantities of most of the food items consumed are smaller than those consumed by large-farm nonadopters, with the only items bucking the trend being fresh meat, sugar, and alcohol, which are higher by 31 percent, 63 percent, and 19 percent, respectively. In light of data on intrahousehold food expenditure patterns in Chapter 7, it may be inferred that the food items whose consumption is higher among hybrid maize adopters are likely to have been purchased by male household members. This could be indicative of the changes taking place in the pattern of intrahousehold resource availability as the result of hybrid maize adoption. In the smaller farm sizes, food items identified as women's purchases are also higher to a smaller extent, but not among the larger farm adopters.

[39]The increased consumption of alcoholic drinks in high-adoption areas is indicative of a high income elasticity. Since most of the drink consumed is local brew, made and sold primarily by women, it may represent a strategy for improving women's income share in high-adopting areas.

Table 34— Daily per capita food consumption, by hybrid maize adoption and farm size

Food Product	Daily per Capita Food Consumption			
	Nonadopters of Hybrid Maize		Adopters of Hybrid Maize	
	Small Farms	Large Farms	Small Farms	Large Farms
	(grams)			
Cereals				
Maize				
Roller and breakfast meal[a]	22	19	7	7
Local	395	528	481	520
Other cereals	33	59	13	13
Roots				
Sweet potatoes	36	43	36	42
Others	6	9	4	6
Groundnuts and beans				
Fresh	16	20	15	12
Dry	38	39	46	48
Vegetables				
Fresh leafy	44	64	43	48
Dried leafy	2	5	2	2
Pumpkin and gourds	107	125	132	123
Others	17	22	18	15
Fruits	23	46	26	21
Meat, fish, and poultry				
Fresh	25	32	26	42
Dried	2	4	1	2
Milk (fresh)	5	12	14	14
Fats and oils	2	1	3	2
Sugar	8	8	10	13
Alcoholic drinks (primarily local beer)	100	165	171	196

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.
aThese are two forms of purchased maize meal.

Seasonal Variations in Dietary Intake

Seasonal variations in food consumption show the extent and severity of food scarcity faced by households during the year. Monthly food consumption observations were grouped to get two-month moving averages between January 1986 and December 1986. The results show that for the sample as a whole, the January-February period was the worst in terms of the macronutrients, with small improvements occurring in March-April (Table 35). Beginning with the harvest months of May-June, substantial improvements occur through July-August, which are sustained in September-October and November-December. It is likely that consumption levels will begin to decline sometime in the January-February period of the following year, with depletion of grain and income from cash sales.

In contrast to the macronutrients, calcium and iron consumption is highest during the periods when caloric intakes are the lowest. The precise reason for this is not clear, and it is likely to be the result of the seasonally high consumption of leafy

Table 35— Daily per capita nutrient intakes, by season

Nutrient	January-February	March-April	May-June	July-August	September-October	November-December
Energy (calories)	1,978.08	2,040.36	2,270.79	2,404.97	2,434.70	2,456.03
	(170.53)	(162.46)	(208.48)	(234.74)	(240.29)	(231.30)
Protein (grams)	55.47	60.55	66.88	67.53	68.07	67.58
	(4.48)	(4.73)	(5.97)	(6.49)	(6.68)	(6.41)
Fat (grams)	24.62	28.60	38.47	37.72	38.56	40.90
	(2.06)	(2.13)	(3.65)	(4.81)	(5.52)	(5.51)
Carbohydrates (grams)	390.89	396.33	401.72	428.21	427.73	428.95
	(35.00)	(32.90)	(37.21)	(39.83)	(39.43)	(37.27)
Calcium (milligrams)	506.60	550.16	500.59	391.02	361.79	354.27
	(39.54)	(42.15)	(44.48)	(39.08)	(37.88)	(32.30)
Iron (milligrams)	23.19	21.22	23.48	21.96	21.16	21.85
	(1.55)	(1.64)	(1.98)	(2.04)	(1.98)	(1.76)
Thiamine (milligrams)	0.88	1.04	1.16	1.09	1.05	1.06
	(0.07)	(0.07)	(0.12)	(0.12)	(0.13)	(0.13)
Riboflavin (milligrams)	0.73	0.80	0.95	1.07	1.20	1.22
	(0.05)	(0.05)	(0.10)	(0.11)	(0.12)	(0.12)
Niacin (milligrams)	10.10	13.19	15.78	15.21	14.31	14.91
	(0.88)	(1.02)	(1.56)	(1.76)	(1.88)	(1.93)

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Note: Numbers in parentheses are standard deviations.

vegetables, which are rich in these components at that time of the year. The B vitamins (thiamine, riboflavin, and niacin) tend to follow a seasonal pattern similar to that of the macronutrients, probably because their main source is the major cereals.

In comparing the differences in seasonal patterns between high- and low-adoption areas, the broad pattern is similar, but some differences emerge. Consumption is lower in low-adoption areas at all times of the year, especially around the "hungry" period (February-March) (Table 36). Low-adoption areas come out of their low earlier (by March-April), while the high-adoption areas do not increase consumption until May-June. This is consistent with the staggered harvest in these areas, which is also reflected in the labor allocation data, and may be due to the greater need in low-adoption areas to harvest crops such as fresh maize, groundnuts, beans, and so forth, while still green, due to the higher degree of seasonal food scarcity there.

High-adoption areas reach their peak consumption level in the postharvest period of July-August; consumption declines slightly from then until the end of the year. In contrast, the jump in consumption in the postharvest period is less perceptible in the low-adoption areas, but consumption increases gradually between September-October and the end of the year (Table 36), probably in response to the higher work requirements at the start of the new crop year.

In contrast to the area-level differences in amounts and seasonal patterns of nutrient consumption, differences at the household level are not that great. This is partly due to the much higher consumption variation between regions than between households within each of the geographical regions. This suggests that the geographical dimensions of consumption change are greater than differences between households in each of the areas. Nonadopters of hybrid maize follow a seasonal pattern similar to that of the low

Table 36—Daily per capita nutrient intakes, by season, for high- and low-adoption areas in the plateau region

	High-Adoption Areas						Low-Adoption Areas					
Nutrient	January-February	March-April	May-June	July-August	September-October	November-December	January-February	March-April	May-June	July-August	September-October	November-December
Energy (calories)	2,199.83	2,187.12	2,576.54	2,746.93	2,652.23	2,577.14	1,288.37	1,657.42	1,597.06	1,704.24	1,922.97	2,141.69
	(307.11)	(269.28)	(351.55)	(390.05)	(352.12)	(374.39)	(95.11)	(63.22)	(133.90)	(27.32)	(222.64)	(344.66)
Protein (grams)	61.29	64.71	76.83	77.08	71.78	70.44	36.82	49.57	46.79	46.48	52.56	55.61
	(7.94)	(8.07)	(9.06)	(10.26)	(9.48)	(10.02)	(3.69)	(1.47)	(4.74)	(1.45)	(4.00)	(6.66)
Fat (grams)	28.03	27.35	48.89	45.05	44.06	44.23	18.79	29.08	24.80	21.58	23.00	27.61
	(3.99)	(1.71)	(2.36)	(4.84)	(6.20)	(6.30)	(0.77)	(0.78)	(2.48)	(2.35)	(1.41)	(2.18)
Carbohydrates (grams)	432.02	435.27	437.78	478.58	454.00	434.90	251.13	306.84	296.31	318.40	356.89	398.64
	(66.35)	(57.16)	(72.90)	(74.67)	(66.09)	(68.54)	(23.49)	(18.98)	(29.37)	(6.45)	(43.39)	(69.92)
Calcium (milligrams)	497.10	519.22	435.82	386.39	336.94	338.96	397.57	495.89	376.72	264.27	246.55	254.27
	(64.90)	(61.23)	(58.96)	(53.48)	(47.98)	(41.61)	(47.63)	(55.31)	(65.55)	(44.22)	(55.96)	(54.41)
Iron (milligrams)	21.77	24.34	22.67	21.86	20.00	18.88	12.72	15.00	16.73	15.73	16.25	17.03
	(3.06)	(2.56)	(2.75)	(2.92)	(2.80)	(2.80)	(0.84)	(1.01)	(2.72)	(1.80)	(1.79)	(2.16)
Thiamine (milligrams)	0.93	1.15	1.20	1.11	0.99	0.92	0.62	0.89	0.88	0.76	0.78	0.83
	(0.09)	(0.09)	(0.11)	(0.12)	(0.15)	(0.16)	(0.14)	(0.01)	(0.24)	(0.19)	(0.19)	(0.21)
Riboflavin (milligrams)	0.72	0.80	1.11	1.21	1.24	1.26	0.59	0.85	0.57	0.79	1.04	1.12
	(0.06)	(0.05)	(0.13)	(0.19)	(0.20)	(0.21)	(0.02)	(0.04)	(0.04)	(0.04)	(0.15)	(0.20)
Niacin (milligrams)	9.75	13.26	18.71	17.41	15.26	15.14	7.43	11.81	9.65	8.65	8.73	9.58
	(1.09)	(1.22)	(1.85)	(2.06)	(2.32)	(2.51)	(1.75)	(0.51)	(1.62)	(1.07)	(0.86)	(1.35)

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Note: Numbers in parentheses are standard deviations.

adoption areas, with no dramatic increase occurring in the postharvest period, but consumption increasing with the onset of the new crop cycle in the September-October period (Table 37). As was seen in the earlier comparisons between these groups, consumption of micronutrients is often found to be higher in the nonadopting households. This is consistently so for calcium and in most of the periods for iron. Differences in intakes of B vitamins are very small and not consistent in any direction.

Observations on seasonal variations in food consumption confirm that the periods of acute scarcity coincide with the latter part of the planting season (January-February) and the preharvest season (March-April). During these stressful periods, the areas where adoption of hybrid maize is low have reduced intake levels. Low-adoption areas have an earlier and prolonged harvest and therefore do not show the postharvest peak consumption of high-adoption areas. This response, as well as the gradual increase in consumption between the harvest and the next peak planting period (November-December), are a clear demonstration of the close link between consumption (especially caloric) and agricultural work in these households.

Multivariate Analysis of Food Consumption

Food consumption is estimated to be a function of area, household, and intrahousehold factors. Area-level factors included are ecology, hybrid maize adoption by area, and degree of access to infrastructure. Household and intrahousehold factors are primarily income, women's share of income, and time spent in household maintenance activities that contribute to food intake. Other characteristics include family size, the dependency ratio, and sex and education of the head of household. In specifying the food consumption equations, the problem of endogeneity of hybrid maize adoption, income, and time allocation is dealt with by specifying instrumental variables to replace these variables. The estimation equation is

$$C_j = f(\log Y^*, Fs, HMm^*, HMf^*, AHm, Ecol, DI, Hsize, Dep, Head, Educ), \qquad (19)$$

where

C_j = dietary variables including household annual average caloric and protein intake per capita (log), and diet diversity measure for total, home-produced, and purchased items (log);
$\log Y^*$ = predicted consumption expenditure (log);
Fs = indicator of women's income share (the proportion of area farmed independently or jointly by females);
HMm^* = predicted value of time allocated to household maintenance by men;
HMf^* = predicted value of time allocated to household maintenance by women;
AHm = area-level hybrid maize adoption (1 = high rate of adoption);
$Ecol$ = ecology (1 = valley);
DI = infrastructure access index (high = poorer access);
$Hsize$ = household size;
Dep = dependency ratio (+60/14-60 years);
$Head$ = sex of the head of household (1 = male); and
$Educ$ = education of the head of household (grades completed).

Table 37—Mean daily per capita nutrient intake by household use of hybrid maize, by seasons

Nutrient	January-February		March-April		May-June		July-August		September-October		November-December	
	Nonhybrid User	Hybrid User	Nonhybrid User	Hybrid User	Nonhybrid User	Hybrid User	Nonhybrid User	Hybrid User	Nonhybrid User	Hybrid User	Nonhybrid User	Hybrid User
Energy (calories)	2,024.69	2,091.58	1,931.04	2,061.14	2,115.70	2,272.01	2,179.64	2,506.62	2,231.06	2,360.95	2,290.55	2,313.72
	(1,125.89)	(1,076.10)	(961.35)	(1,015.78)	(1,189.17)	(1,130.83)	(1,255.19)	(1,282.54)	(1,401.52)	(1,195.78)	(1,479.89)	(1,218.24)
Protein (grams)	58.05	59.77	58.29	61.87	63.45	66.80	62.10	69.49	63.43	63.48	63.09	63.30
	(32.40)	(34.56)	(28.42)	(33.17)	(36.57)	(31.28)	(33.77)	(35.44)	(39.01)	(32.07)	(49.45)	(33.40)
Fat (grams)	23.07	30.09	26.59	27.67	35.62	39.89	30.55	39.30	30.84	37.42	32.32	38.97
	(21.68)	(28.84)	(19.87)	(17.31)	(32.10)	(33.33)	(28.17)	(32.41)	(32.02)	(32.43)	(32.38)	(32.05)
Carbohydrates (grams)	406.33	401.29	371.00	406.52	374.89	394.17	396.75	440.66	402.86	407.22	415.06	394.17
	(227.63)	(208.93)	(195.80)	(212.90)	(209.21)	(213.59)	(223.91)	(225.12)	(242.74)	(201.25)	(256.79)	(204.06)
Calcium (milligrams)	573.86	461.52	573.13	458.34	516.26	409.99	379.40	347.43	368.84	282.99	350.12	299.51
	(408.75)	(292.62)	(390.12)	(290.55)	(415.63)	(226.63)	(259.58)	(207.48)	(410.79)	(188.78)	(343.02)	(208.52)
Iron (milligrams)	32.23	21.10	20.93	22.08	24.69	20.35	21.99	19.97	21.51	17.79	23.86	18.06
	(39.00)	(21.53)	(15.62)	(13.20)	(25.75)	(10.67)	(14.96)	(10.73)	(16.52)	(9.56)	(43.75)	(10.64)
Thiamine (milligrams)	1.03	0.83	0.99	1.08	1.10	0.99	0.99	0.98	0.92	0.84	0.93	0.82
	(0.87)	(0.60)	(0.65)	(0.70)	(0.82)	(0.64)	(0.73)	(0.66)	(0.80)	(0.62)	(0.78)	(0.67)
Riboflavin (milligrams)	0.81	0.69	0.82	0.68	0.86	0.94	0.93	1.11	1.03	1.13	1.12	1.09
	(0.56)	(0.53)	(0.80)	(0.40)	(0.67)	(0.53)	(0.65)	(0.66)	(0.83)	(0.63)	(0.84)	(0.64)
Niacin (milligrams)	10.89	9.72	12.85	12.69	15.45	14.81	14.08	14.78	12.81	12.69	13.14	13.01
	(7.49)	(7.01)	(8.56)	(7.91)	(12.34)	(9.50)	(10.38)	(10.42)	(10.76)	(9.97)	(11.50)	(10.08)

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Note: Numbers in parentheses are standard deviations.

Results of the estimations are presented in Table 38. The instrumented variable for income is insignificant for both calorie and protein measures.[40] This suggests that increases in food consumption that occurred with higher income are likely to be associated with an increase in household labor allocation in agriculture and may not lead to any *net* improvements in caloric intakes. Income increase, however, contributes to an improvement in diet diversity, as measured by the number of food groups represented in the diet. This improvement occurs in both home-produced (statistically significant) and purchased components, and it is indicative of an improvement in the quality of the diet. The women's income share indicator, in contrast with overall household income, is consistently and significantly positive for all the dietary components analyzed. Also, the amount of time spent by women in household maintenance activities is significantly positive for both calories and protein.

Two area-level variables, infrastructure (access to roads, markets, and services) and degree of local adoption of hybrid maize, had significant effects on consumption parameters.[41] Better infrastructure development had a statistically significant negative effect on all the dietary parameters analyzed. Per capita calorie and protein intakes as well as diet diversity are higher in locations with poor access to infrastructure. It is not certain that this necessarily means that dietary adequacy is better in poorly developed areas, since it was seen earlier that labor allocation in all activities was higher in the poor infrastructure areas. It could also reflect the limited opportunity to obtain non-food consumer items in poor infrastructure areas. Most of the increase in diet diversity in poor infrastructure areas comes from own-produced food items.

A high level of hybrid maize adoption in an area had a significantly positive impact on the dietary calorie and protein consumption levels, and on the number of food items from home production in the diet. However, the number of purchased food items is reduced. These results are consistent with the earlier tabular analysis. The scale of dietary improvement in high-adoption areas is about 600 calories and 9 grams of protein per capita per day. These improvements are likely to be the result of better local availability of farm products. Such improvements in food supply are generally expected with adoption of improved grain varieties. Normally, they would be reflected in price variations, but they are poorly captured through modeling of regional price variation in Eastern Province, due to fragmented and price-controlled markets (Holleman 1991).

Larger families have lower per capita calorie and protein consumption, but better diversity according to food count measures, indicating that there are economies of scale in improving diet diversity. The expanded ability of households with additional members to gather naturally obtained food items, such as leafy vegetables, fish, and small wild animals, is also likely to be a factor in the improved food diversity in larger families.

Households headed by males have statistically significant higher caloric and protein levels, but this does not hold true for any of the diet diversity measures. An

[40]This is in contrast to a calorie income elasticity of 0.5 obtained using measured income (consumption expenditure). The Hausman test confirms the need for the use of the instrumented variable.

[41]The correlation coefficient between the infrastructure access and area-level hybrid maize adoption variables was small and insignificant. This could be due to the importance of the provincial cooperative union (EPCU) and its local branches in providing inputs, especially credit, to its members.

Table 38—Regression summary of consumption and food diversity

Independent Variable	Mean	Log Calories per Capita: Coefficient	t-Ratio	Log Protein per Capita: Coefficient	t-Ratio	Log Total Food Count: Coefficient	t-Ratio	Log Total Food Count, Home-Produced: Coefficient	t-Ratio	Log Total Food Count, Purchased: Coefficient	t-Ratio
FAMILSZ2	5.9	−0.0999	−4.53*	−0.0831	−3.98*	0.0456	2.91*	0.0380	2.46*	0.0994	2.31*
HEADHH	0.8	0.1833	2.03*	0.1468	1.72	0.0021	0.03	0.0049	0.08	−0.0428	−0.24
DEPRATIO	1.1	−0.0637	−1.66	−0.0608	−1.67	0.0100	0.37	0.0273	1.01	−0.0065	−0.09
EDHHLD	3.8	0.0015	0.24	−0.0050	−0.85	0.0080	1.83	−0.0008	−0.20	0.0289	2.40*
VALLPLAT	0.2	−0.0119	−0.05	0.0644	0.27	−0.0855	−0.47	−0.0231	−0.13	−0.7320	−1.46
HMADOPT	0.4	0.2471	5.83*	0.2414	6.02*	0.0139	0.46	0.1139	3.83*	−0.2596	−3.15*
AREADINF	1.4	0.0501	2.04*	0.0707	3.04*	0.0922	5.29*	0.1087	6.31*	0.1792	3.75*
PFFIJ	0.6	0.1794	2.85*	0.1217	2.04*	0.1842	4.12*	0.1629	3.69*	0.3994	3.26*
FLOGYC	4.0	0.1394	0.59	0.2201	0.99	0.3181	1.91*	0.3263	1.98*	0.7239	1.58
FMMAINT	48.6	−0.0026	−0.78	−0.0029	−0.92	0.0021	0.88	0.0031	1.33	0.0042	0.66
FFMAINT	669.6	0.0005	3.46*	0.0003	2.61*	−0.00004	−0.43	0.00001	0.14	−0.0003	−1.08
Constant		7.1583	6.72	3.33	3.30*	0.9417	1.24	0.5976	0.80	−1.9364	−0.93
R^2 (adjusted)		0.69		0.70		0.44		0.52		0.32	
F		44.1		46.9		16.3		22.1		9.9	
Sample (N)		213		213		213		213		213	

Notes: The definitions of variables are as follows:

FAMILSZ2 = Family size;
HEADHH = Sex of head of household: 1 = male, 0 = female;
DEPRATIO = Dependency ratio: + 60 / 14-60;
EDHHLD = Education of household head, grades completed;
VALLPLAT = Valley or plateau: 1 = valley, 0 = plateau;
HMADOPT = Area-level hybrid maize adoption: 1 = high, 0 = low;
AREADINF = Area-level infrastructure index based on distance to 12 elements; the higher the index, the poorer the infrastructure;
PFFIJ = Proportion of area farmed by female, independently and jointly;
FLOGYC = Predicted log of per capita consumption expenditure;
FMMAINT = Predicted male maintenance labor hours per year; and
FFMAINT = Predicted female maintenance labor hours per year.

*Significant at the .05 level.

increase in the education of the head of household has a positive effect on the amount of food purchased, which is likely to be related to the higher returns in the nonfarm sector of more educated household heads (see Chapter 6), and, hence, a reduced reliance on agricultural production for meeting food needs.

To sum up the main observations related to the effects of hybrid maize adoption, there is strong evidence of simultaneity between food consumption and household income (as measured by total consumption expenditure) in the study area. When an instrumented variable is used for household income, there is no statistically significant effect on consumption of calories or protein. This is in sharp contrast to a significant (more than 0.5) income elasticity for calories when observed income is used. There is, however, an improvement in diet diversity, primarily from own sources. Households headed by men have a higher consumption level, which could be a function of their better access to technology and other resources. However, in all types of households, increasing the share of women's income increases the allocation of income to food consumption—and this is statistically significant for all the dietary measures analyzed. Time spent by women in support activities related to household consumption is also found to be positive and statistically significant. Areas with a high degree of hybrid maize adoption have significantly higher food consumption than low adoption areas, with a higher variance between these areas than within high or low adoption areas. The other area-level variable, degree of infrastructure development, was found to reduce all of the dietary measures analyzed here. It is not certain whether this finding is the result of changing patterns of consumer preference with wider availability of goods in better infrastructurally developed areas or due to changes in income and labor allocation patterns or both.

9

EFFECTS ON HEALTH AND NUTRITIONAL STATUS

Links with Technological Change in Agriculture

The etiology of nutritional status is composed of two broad and interlinked sets of conditions—diet and disease (Payne 1990). Food consumption, as discussed earlier, is primarily determined by household income, price and availability, and intrahousehold resource allocation or preference patterns for food—all of which can be influenced by technological change in agriculture. Although household diets and dietary adequacy may be good predictors of individual dietary adequacy, the degree of dispersion is high for both macro- and micronutrients. Although empirical analysis of individual vis-à-vis household-level dietary adequacy has been scant, investigations have generally shown that household intake of nutrients is one of the best predictors of individual nutrient adequacy (Kumar and Bhattarai 1992).

The evidence is clear: in the short run, disease episodes or related chronic conditions lower nutritional status. However, knowledge is growing about the different ways in which nutrient deficiencies, particularly micronutrients and protein, can themselves contribute to disease susceptibility (Campbell 1991). Quality of child care and external conditions in the environment that influence exposure to infections also contribute to disease. Technological change can influence the disease component of nutritional status etiology in various ways. First, improvements in household income and allocation of income to diet and nutrient adequacy contribute to better immunocompetence or resistance to disease.[42] Second, improvements in income can lead to improvements in environmental conditions such as housing, water supply, and sanitation that help to reduce exposure to infections. Income improvements could also lead to better utilization of health services available to the community. Third, other environmental changes may occur in the course of technological change in agriculture that could have positive or negative health consequences. One that is most often mentioned is the increase in irrigation and its effect on increased exposure to waterborne diseases, such as schistosomiasis, bilharzia, and diarrheal disease.

[42]Malaria is the only common disease for which there are some claims in the literature that improvement in intake of some nutrients (for example, iron) increases susceptibility to the disease. Recent evidence, however, shows that nutrition in children and iron nutrition (serum ferritin), in particular, are correlated with a larger number of parasites present in malaria attacks but do not increase susceptibility (Snow et al. 1991).

In the present analysis, a descriptive examination of health and nutrition conditions is carried out, followed by a multivariate analysis of child nutritional status. The sample consists of individuals in the study households.

Incidence of Disease

In analyzing illness rates for the most common diseases by age group, this report finds that illness rates for individuals in this sample of households are lower than those reported in other, more densely populated parts of Sub-Saharan Africa. In this study, children under 3 years old were seriously ill only 15 days a year, compared with about 90 days for preschoolers in South Nyanza District of Kenya (Kennedy and Cogill 1987). For the younger children, malaria is the most frequently reported illness, with nearly every child under 3 years having at least one episode during the year (Table 39). Children under 3 years also had about one episode of a respiratory illness with fever during the year. The rate of infection with diarrhea in the youngest group of children was the lowest of the three types of infections, with only four episodes for every 10 children under 3 years, compared with eight episodes of malaria and seven episodes of other infections. Rates for all illnesses were sharply lower for the 3-to-5-year-olds and the 5-to-14-year-olds, compared with the under-3-year-old group. Rates increased again, however, for the over-14-year-olds, especially for females in that age group.

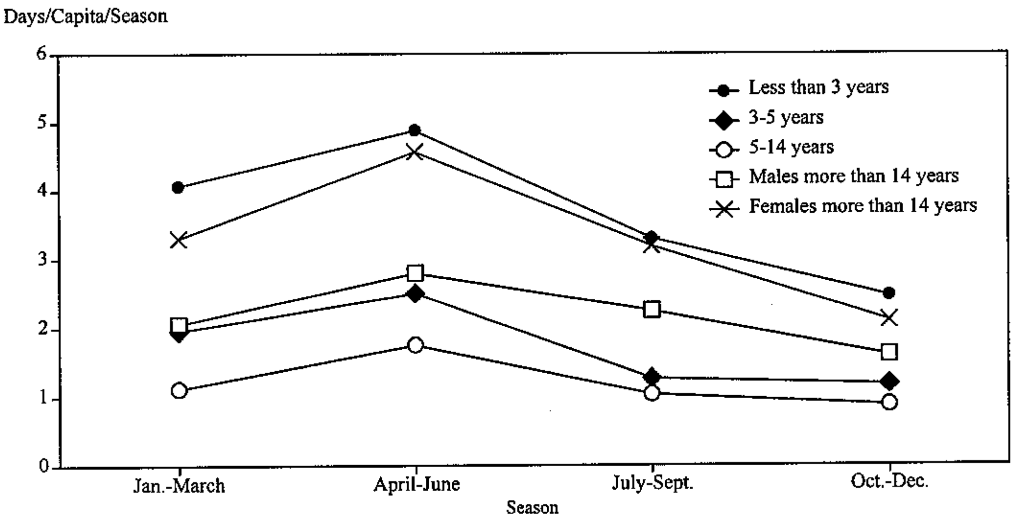
Seasonal fluctuations in days ill for each age group are presented in Figure 9. The four periods represent the four quarters of the year: January-March, April-June, July-September, and October-December. Seasonally, diarrhea and malaria rates are highest in the first two quarters, during and following the peak rainfall. Other illnesses including respiratory are most prevalent in the second quarter. Overall, the second quarter, April-June, appears to be the worst in the year for illness. This period coincides with the end of the rains and includes the pre- and early-harvest period, the time when people are most likely to be vulnerable to disease, due to the cumulative effects of the preceding hungry season. Children under 3 years and female aduts have

Table 39— Illness rates

	Annual Episodes of Disease per Person				Annual Days Ill per Person			
Age Group	Diarrhea	Malaria	Miscel-laneous Fevers	All Illnesses	Diarrhea	Malaria	Miscel-laneous Fevers	All Illnesses
Less than 3 years	0.4	0.8	0.7	1.9	3.1	4.4	7.2	14.7
3 - 5 years	0.1	0.4	0.4	0.9	0.6	2.5	3.8	6.9
5 - 14 years	0.1	0.3	0.3	0.7	0.4	1.7	2.7	4.8
Over 14 years								
Male	0.1	0.3	0.6	1.0	0.5	1.5	6.9	8.9
Female	0.2	0.4	0.8	1.4	1.3	2.1	9.9	13.3

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Figure 9—Days ill with diarrhea, malaria, and other infections



Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

the highest illness rates in the population, and this is also reflected in the seasonal distribution of days ill.

Area-level comparisons indicate that valley sites have a higher rate of diarrheal disease (both for number of episodes and days ill) compared with the plateau, and, in most age groups, for fevers and respiratory diseases. Overall, however, malaria infections are more prevalent in the plateau areas (Table 40). A comparison of areas with high and low adoption of hybrid maize shows that high-adoption areas are similar or higher in diarrheal disease incidence for most of the age groups, whereas they are generally lower in malarial disease incidence. There is no clear pattern for other fevers and respiratory infections. At the household level, for children under 5 years and females over 14 years, nonadopting households have a higher rate of diarrhea and malaria, both in episodes and days ill (Table 41). The pattern is not clear-cut for the other age groups. Moreover, for males over 14 years, the hybrid-adopting households seem to have a higher illness rate.

Areas with high hybrid maize adoption also generally have a better water and sanitation situation (Table 42). The difference in the first quarter is smaller than that in the later periods, probably due to the frequent disrepair of the protected water sources in many areas. At the end of the survey, about 45 percent of households in the high-adoption areas had access to protected water, but less than 20 percent in the low-adoption areas did. Similarly, nearly 30 percent of households in high-adoption areas had pit latrines, while only about 15 percent in the low-adoption areas did.

At the household level, adoption of hybrid maize and access to protected water and sanitation did not seem to be related; no differences in this respect were found between low- and high-adoption households. Correlation coefficients indicate that

Table 40—Disease episodes and duration per person by region and high- and low-adoption areas

Age Group/Disease	Valley	N	Plateau	N	Plateau: Low-Adoption Areas	N	Plateau: High-Adoption Areas	N
Less than 3 years								
Diarrhea								
Number of times	0.82	34	0.31	149	0.22	70	0.39	79
Number of days	5.80	34	2.50	149	2.35	70	2.59	79
Malaria								
Number of times	0.77	34	0.75	149	1.06	70	0.48	79
Number of days	2.80	34	4.80	149	7.11	70	2.75	79
Other infections								
Number of times	1.02	34	0.63	149	0.70	70	0.58	79
Number of days	10.30	34	6.50	149	8.00	70	5.11	79
3 - 5 years								
Diarrhea								
Number of times	0.22	19	0.10	96	0.05	48	0.15	48
Number of days	1.12	19	0.54	96	0.32	48	0.75	48
Malaria								
Number of times	0.11	19	0.47	96	0.56	48	0.39	48
Number of days	0.47	19	2.90	96	3.32	48	2.42	48
Other infections								
Number of times	0.56	19	0.33	96	0.31	48	0.35	48
Number of days	4.40	19	3.70	96	2.33	48	5.07	48
5 - 14 years								
Diarrhea								
Number of times	0.22	47	0.06	169	0.02	81	0.09	88
Number of days	1.03	47	0.23	169	0.10	81	0.35	88
Malaria								
Number of times	0.30	47	0.28	169	0.41	81	0.16	88
Number of days	1.04	47	1.85	169	2.80	81	0.93	88
Other infections								
Number of times	0.39	47	0.27	169	0.30	81	0.25	88
Number of days	4.22	47	2.29	169	2.59	81	2.00	88
More than 14 years								
All								
Diarrhea								
Number of times	0.39	63	0.06	252	0.06	121	0.07	131
Number of days	2.70	63	0.41	252	0.42	121	0.40	131
Malaria								
Number of times	0.39	63	0.31	252	0.34	121	0.29	131
Number of days	1.88	63	1.91	252	2.11	121	1.73	131
Other infections								
Number of times	1.19	63	0.65	252	0.65	121	0.64	131
Number of days	14.20	63	7.59	252	8.80	121	6.50	131
Male								
Diarrhea								
Number of times	0.23	54	0.05	229	0.03	104	0.06	125
Number of days	1.20	54	0.30	229	0.15	104	0.42	125
Malaria								
Number of times	0.33	54	0.23	229	0.26	104	0.20	125
Number of days	1.82	54	1.38	229	1.52	104	1.26	125
Other infections								
Number of times	1.01	54	0.53	229	0.46	104	0.59	125
Number of days	11.79	54	5.77	229	4.70	104	6.66	125

(continued)

Table 40—Continued

Age Group/Disease	Valley	N	Plateau	N	Plateau: Low-Adoption Areas	N	Plateau: High-Adoption Areas	N
Female								
Diarrhea								
Number of times	0.52	63	0.09	249	0.09	119	0.08	130
Number of days	3.96	63	0.60	249	0.84	119	0.39	130
Malaria								
Number of times	0.39	63	0.36	249	0.39	119	0.33	130
Number of days	1.76	63	2.18	249	2.41	119	1.96	130
Other infections								
Number of times	1.31	63	0.73	249	0.73	119	0.72	130
Number of days	16.20	63	8.36	249	10.36	119	6.53	130

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.
Note: N indicates the size of the sample.

protected water and sanitation are more likely to be available in areas with better access to health services and an overall higher adoption rate for hybrid maize.

Children's Nutritional Status

The three commonly used indices of children's nutritional status examined here are weight-for-age, height-for-age, and weight-for-height. In order to construct them, children's weight and height are compared with internationally accepted standard values for growth of children with age (WHO 1983). There are several ways of using these indices (Beaton et al. 1990). One way is to assess the prevalence of malnutrition; another is to assess differences in actual levels of weight or height attainment between groups. Two types of instruments are available based on the standards:

1. The position of the child's measurements on the normal distribution for his or her age, expressed in Z-scores. A Z-score below –2 indicates that the measure is more than 2 standard deviations below the "normal" population. This is an appropriate measure to use in assessing malnutrition, because the dispersion of measures in a normal population varies widely by age of children. Thus, at some ages, a lower percentage of the median values might be within the acceptable range, given the high level of variation, while, at other ages with a lower degree of variation, a higher percentage of the median values may be an appropriate cutoff point. Hence, the –2 Z-score is a useful measure to use.
2. The other instrument widely used relates the measures to the reference as a percentage of the median (commonly accepted as the standard reference measure for growth of "normal" children). This measure is more explicit in comparing the growth achievement of children to the standard. Both the –2 Z-score cutoff point and the percentage of the median reference population are used in this analysis.

Table 41—Disease episodes and duration per person by region and hybrid maize adoption by households

Age Group/Disease	Nonadopting Households				Adopting Households	
	Valley	N	Plateau	N	Plateau	N
Less than 3 years						
Diarrhea						
Number of times	0.83	33	0.35	76	0.26	67
Number of days	5.70	33	3.40	76	1.56	67
Malaria						
Number of times	0.77	33	0.97	76	0.54	67
Number of days	2.65	33	6.33	76	3.33	67
Other infections						
Number of times	1.06	33	0.62	76	0.67	67
Number of days	10.58	33	6.54	76	6.74	67
3 - 5 years						
Diarrhea						
Number of times	0.23	19	0.13	51	0.07	41
Number of days	1.12	19	0.75	51	0.32	41
Malaria						
Number of times	0.11	19	0.56	51	0.39	41
Number of days	0.47	19	3.84	51	1.77	41
Other infections						
Number of times	0.56	19	0.28	51	0.33	41
Number of days	4.35	19	4.05	51	3.05	41
5 - 14 years						
Diarrhea						
Number of times	0.21	45	0.05	99	0.07	65
Number of days	1.02	45	0.19	99	0.29	65
Malaria						
Number of times	0.31	45	0.27	99	0.30	65
Number of days	1.06	45	1.85	99	1.94	65
Other infections						
Number of times	0.39	45	0.24	99	0.38	65
Number of days	4.19	45	2.11	99	2.66	65
Over 14 years						
All						
Diarrhea						
Number of times	0.39	61	0.05	149	0.08	92
Number of days	2.80	61	0.39	149	0.48	92
Malaria						
Number of times	0.39	61	0.35	149	0.26	92
Number of days	1.91	61	2.24	149	1.47	92
Other infections						
Number of times	1.22	61	0.70	149	0.59	92
Number of days	14.40	61	8.60	149	6.45	92
Male						
Diarrhea						
Number of times	0.22	52	0.02	128	0.09	91
Number of days	1.19	52	0.18	128	0.49	91
Malaria						
Number of times	0.34	52	0.22	128	0.23	91
Number of days	1.89	52	1.29	128	1.42	91
Other infections						
Number of times	1.05	52	0.47	128	0.63	91
Number of days	12.25	52	4.76	128	7.48	91

(continued)

Table 41—Continued

Age Group/Disease	Nonadopting Households: Valley	N	Plateau	N	Adopting Households: Plateau	N
Female						
Diarrhea						
Number of times	0.53	61	0.08	147	0.09	92
Number of days	4.07	61	0.71	147	0.46	92
Malaria						
Number of times	0.40	61	0.41	147	0.29	92
Number of days	1.78	61	2.66	147	1.55	92
Other infections						
Number of times	1.34	61	0.82	147	0.59	92
Number of days	16.42	61	10.03	147	6.13	92

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Note: N indicates the sample size.

Malnutrition in children is found to vary sharply from season to season. Of the four measures taken during the year, those in February were found to be the worst, with 24 percent of children under 5 years and 28 percent of those 5-to-10 years old having Z-scores below –2 standard deviation for weight-for-age (Table 43). This period was also the worst in terms of the short-term measure of malnutrition—

Table 42—Water and sanitation, by hybrid maize adoption

Water and Sanitation Indicator	Plateau: Low-Adoption Areas: Nonhybrid User		Low-Adoption Areas: Hybrid User		High-Adoption Areas: Nonhybrid User		High-Adoption Areas: Hybrid User	
Drinking source								
Season 1								
0 Shallow dug-out, river, stream, dam	39	(60.9)	11	(61.1)	20	(40.8)	22	(45.8)
1 Protected well or borehole, tap	25	(39.1)	7	(38.9)	29	(59.2)	26	(54.2)
Season 2								
0 Shallow dug-out, river, stream, dam	41	(100.0)	15	(100.0)	29	(50.0)	32	(55.2)
1 Protected well or borehole, tap	0	(0.0)	0	(0.0)	29	(50.0)	26	(44.8)
Season 3								
0 Shallow dug-out, river,stream, dam	61	(77.2)	19	(86.4)	32	(58.2)	37	(59.7)
1 Protected well or borehole, tap	18	(22.8)	3	(13.6)	23	(41.8)	25	(40.3)
Season 4								
0 Shallow dug-out, river,stream, dam	61	(80.3)	17	(85.0)	31	(51.7)	38	(56.7)
1 Protected well or borehole, tap	15	(19.7)	3	(15.0)	29	(48.3)	29	(43.3)
Latrine								
0 No	74	(85.1)	20	(83.3)	44	(71.0)	48	(70.6)
1 Yes	13	(14.9)	4	(16.7)	18	(29.0)	20	(29.4)

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Notes: Numbers in parentheses are column percentages.

Table 43— Malnutrition in children, Eastern Province, 1986

Anthropometric Indicator	Total Sample: Less than 5 Years	Total Sample: 5-10 Years	Valley: Less than 5 Years	Valley: 5-10 Years	Plateau: Less than 5 Years	Plateau: 5-10 Years
	(percent below −2 Z-score)					
Round 1 (February 1986)						
Weight-for-age	24.2	27.9	5.6	13.3	26.2	29.9
Height-for-age	53.0	59.8	44.6	40.0	53.9	62.6
Weight-for-height	5.0	5.1	0.0	7.1	5.6	4.9
Round 2 (May-June 1986)						
Weight-for-age	12.4	14.9	23.7	8.0	10.5	16.3
Height-for-age	53.1	38.5	45.9	24.0	54.3	41.5
Weight-for-height	2.4	2.8	2.7	5.3	2.3	2.5
Round 3 (September 1986)						
Weight-for-age	15.4	15.1	19.5	18.2	14.5	14.4
Height-for-age	48.5	30.2	41.5	30.3	50.0	30.2
Weight-for-height	0.0	3.6	0.0	6.7	0.0	2.9
Round 4 (November 1986)						
Weight-for-age	20.6	7.5	16.7	2.8	21.6	9.3
Height-for-age	51.3	19.5	41.7	11.1	53.8	22.7
Weight-for-height	1.3	5.6	4.3	12.9	0.5	3.2

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

weight-for-height—with about 5 percent of children in both age groups malnourished according to this indicator. Malnutrition is greatly reduced between February and June, the level halving for both weight-for-age and weight-for-height. Moreover, catch-up growth in heights of the 5-to-10-year olds is substantial and continues for the rest of the year. While some indicators, for example, weight-for-height of those under 5 years old and height-for-age for the 5-to-10-year-old group, continue to improve through September, weight increments with respect to age appear to have leveled off after June, and they begin to deteriorate again toward the end of the year for those under 5 years old. This decline is primarily due to the faltering growth of those under 3 years old at that time. Overall, there is more seasonal variation in nutritional status in the youngest children, with the older 5-to-10-year-old group exhibiting considerable catch-up growth from the low February levels.

Area-level comparisons indicate that the overall pattern of seasonal variation in nutritional status closely mirrors the situation on the plateau, with the valley areas showing a different and not entirely clear-cut seasonal pattern for children of different age groups (Table 43).

Comparison of child malnutrition by area- and household-level hybrid maize adoption during the worst time of the year shows a generally higher prevalence of malnutrition in those under 5 years old in the areas with low adoption.[43] The difference is smaller for household-level adoption, with nonadopting households showing a slightly higher (not statistically significant) prevalence of malnutrition for the under-

[43]This is statistically significant for weight-for-height only.

Table 44—Malnutrition in children, by adoption of hybrid maize, Eastern Province, February 1986

Adoption of Hybrid Maize	Less than 5 Years Old			5-10 Years Old		
	Weight-for-Age	Height-for-Age	Weight-for-Height	Weight-for-Age	Height-for-Age	Weight-for-Height
	(percent below −2 Z-score)					
Area level						
High	22.8	58.8	0.0	38.0	64.0	10.4
Low	29.4	49.4	11.0	22.8	61.4	0.0
Household level						
Adopters	25.0	50.0	4.5	34.1	70.5	2.4
Nonadopters	26.6	56.8	6.5	28.3	55.0	6.9

Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

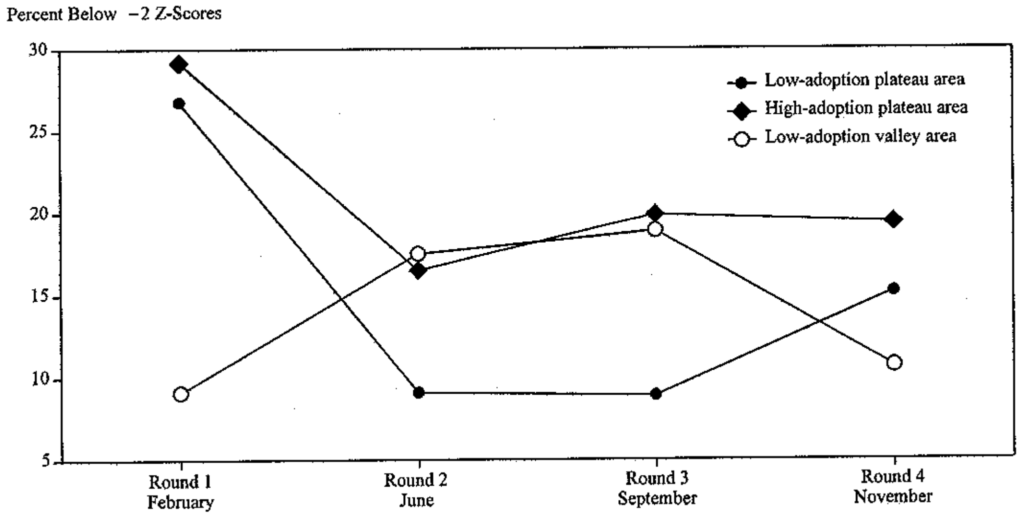
5-year-old group for all three indicators (Table 44). When a similar comparison is made for the 5-to-10-year olds, the reverse is found. Areas with high adoption rates have a consistently higher prevalence of malnutrition among the 5-to-10-year olds for all three nutrition indicators.[44] When this comparison is made, taking household-level adoption as the discriminating condition, the same observation is made. However, the prevalence of malnutrition is higher, based on the longer-term weight-for-age and height-for-age indicators, except for the short-term weight-for-height indicator, which is lower in the nonadopting households.[45] The difference in the situation between the younger and older children during the February measurements, which coincides with the relatively heavy agricultural work season (for hybrid maize adopters), could be due to the relatively heavier workload of all family members, including children, in households with hybrid maize adoption. It could also be indirectly due to the heavier workload of women, who carry the youngest children with them when they go to work but may leave the older ones behind in the village with neighbors or relatives. When the observations for all children below 10 years are combined, the low-adoption areas of the plateau show a lower level of child malnutrition than high-adoption areas of the plateau. Valley areas, with their inverted seasonal pattern (lower prevalence in February and November and a higher prevalence in June and September), show the lowest levels of child malnutrition in February and November (Figure 10).

Child nutrition by household-level hybrid maize adoption shows a different pattern for small and large farms (the median farm size for each group was taken as the cutoff point for the farm size classification). Among nonadopters, large farms have a slightly lower percentage of undernutrition for all children under 10 years than small-farm nonadopters. This is consistent with results generally obtained that show small improvements in child nutrition with increasing incomes. The pattern by farm

[44]This is statistically significant for weight-for-age, and marginally so for weight-for-height (significant at the .07 level).

[45]The differences in weight-for-age and weight-for-height are, however, not statistically significant, and the height-for-age is marginally significant with $P_o = .07$.

Figure 10—Percent of children who are below –2 Z-scores of weight-for-age in areas of high and low adoption of hybrid maize



Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Note: Includes children less than 10 years old. The Z-score is a method used in standardizing the distribution of actual weight of the child relative to the standard weight for a child of that sex and age.

size for hybrid maize adopters is, however, reversed. Small farmers who adopt hybrid maize have a lower prevalence of undernutrition by the end of the survey than any other group. Large-farm adopters, in contrast, are worse off than all of the other groups (Figure 11).

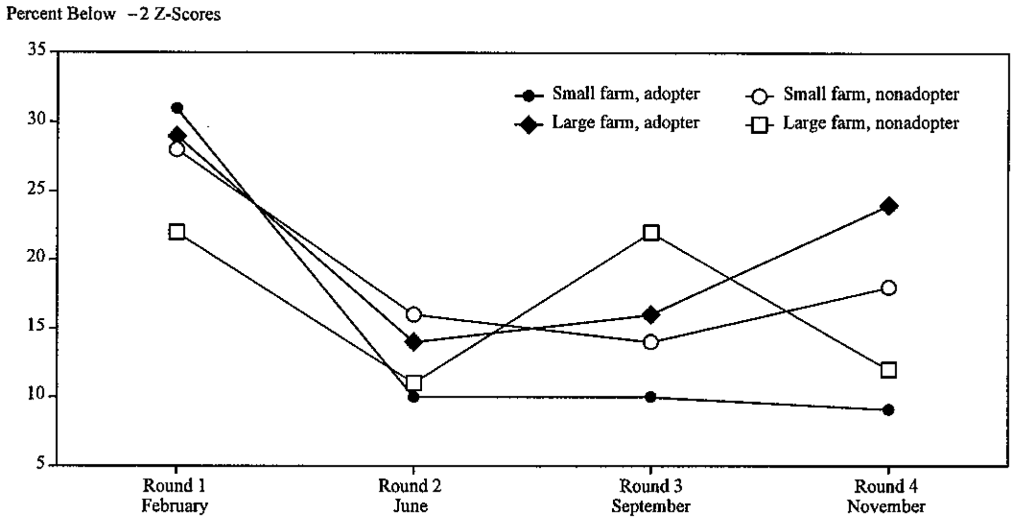
Variations in Adult Weights

Levels of and changes in adult weights can be interpreted in terms of their body mass index (BMI), which is a height-independent measure that reflects the extent of adiposity or fat stores in the body.[46] Though the BMI has been used most often in assessing the extent of obesity in a population, it can be adapted to assess undernutrition in adults as well. At present, there is much debate about its usefulness in measuring degree of undernutrition,[47] its comparability across populations (Norgan 1990; Immink, Flores, and Diaz 1992), and its functional significance (Kennedy and Garcia 1992). Despite the ongoing debate, no other measure is available as a substi-

[46]BMI = Body weight (Kilogram)/Height (M) squared.

[47]In assessing obesity in Western populations, the commonly used range for "normal" BMI is 20-25, with values greater than 25 used to denote various degrees of overweight. In many low-income countries, such as in India and Ethiopia, much lower values for BMI are commonly observed, and this has led many authors to propose lower cutoff points to denote "normal" values.

Figure 11—Percent of children who are below –2 Z-scores of weight-for-age by household level of hybrid maize adoption and farm size



Source: International Food Policy Research Institute, Rural Development Studies Bureau, Eastern Province Agricultural Development Project, and National Food and Nutrition Commission agricultural household survey, Eastern Province, Zambia, 1985/86.

Note: Includes children less than 10 years old. The Z-score is a method used in standardizing the distribution of actual weight of the child relative to the standard weight for a child of that sex and age.

tute for BMI in comparing weight differences between groups of adults while controlling for height.

In the present sample of households, adults averaged 20.5-22.0 BMI during the four seasons. The lowest point was in February for both low and high hybrid-maize-adopting areas, with the high-adopting areas showing a large increase in weight between February and June. Low-adopting areas catch up between June and September, finally reaching the same BMI level as the adults in the high-adopting areas. Both groups of households had a lower BMI between the postharvest month of September and November, when work on the next crop season begins.

A similar comparison of BMIs of members of households that were hybrid maize adopters with those that were nonadopters shows that those in adopting households gained more weight between the low point in February and the postharvest measurement in September. In both groups, household members began to lose weight between the September and November measurements, but the rate of decline was greater for the nonadopting households. These observations indicate that although adopting households reach an annual postharvest weight that is higher than the nonadopters, both groups of households face seasonal weight losses that coincide with the heavy work season in agriculture. However, adopting households may have a somewhat better ability to recover from the seasonally lowest point. In the case of adults, those from both small and large farms showed similar changes within each adoption category.

Multivariate Analysis of Children's Nutritional Status

In order to model the determinants of child nutritional status as measured by anthropometry, the exogenous variables are considered to be the determinants of the interrelated diet and health inputs available to the child. In accordance with this, household-level characteristics included in the equations were

1. household per capita consumption expenditure;
2. household characteristics that influence allocation of resources, including women's share of resources as given by their crop ownership, sex of head of household, education and age of head of household, dependency ratio, and a proxy variable for mother's height;
3. time spent in household maintenance activities by men and women;
4. health-influencing conditions, including access to protected water and sanitation and distance to health services;
5. child characteristics, including age and sex; and
6. seasonal variations in the form of seasonal dummies for rounds 2, 3, and 4 (June, September, and November).

Instrumented variables were not used in the child nutrition equations, as these are not expected to be endogenous to the measured household income and time allocation. A "random effects" model was used to incorporate seasonal effects during the year. The dependent variables were Z-scores for weight-for-age, height-for-age, and weight-for-height of all children up to 10 years of age. The interpretation of the three indicators is based on the time frame within which they undergo change. Since height-for-age is the most cumulative of the three, it is interpreted as indicative of longer-term nutritional status. Weight-for-height changes most rapidly and can be altered on a week-to-week basis, especially by illness or change in food consumption. Weight-for-age is a composite of the longer-term height-for-age and the shorter-term weight-for-height indicators. Results are presented in Table 45. The adjusted R squares are low, as is commonly observed in anthropometric regressions that do not include variables reflecting the cumulative nature of the anthropometric variable's formation. Though only about 10 percent of the variations in the anthropometric measurements during the year can be explained by the current status of the exogenous variables, the extent to which they are significant indicates their role in shaping the current and presumably ongoing nutritional status development of the children. To the extent that the unmeasured historical variations are randomly distributed in the population, they should not impinge on the robustness of the parameter estimates (von Braun, de Haen, and Blanken 1991).

Results indicate that both household income, as measured by per capita consumption expenditure, and women's resource access, as measured by their share of crop acreage farmed independently or jointly, are significantly positive for the longer-term nutritional status indicators of weight-for-age and height-for-age. In relating this result to adoption of hybrid maize, there is an explanation for the unclear results of adoption on improvement in child nutrition. While income was found to increase

Table 45— Anthropometric regression summary: Random effects model, 10 years and under

Independent Variable	Mean	Weight-for-Age Z-Scores Coefficient	t-Ratio	Height-for-Age Z-Scores Coefficient	t-Ratio	Weight-for-Height Z-Scores Coefficient	t-Ratio
YC	51.7	0.002791	1.14	0.006408	1.99*	−0.00259	−0.96
PFFIJ	0.6	0.067701	0.47	0.37279	1.95*	−0.16807	−1.06
DEPRATIO	1.4	0.063871	0.81	0.15746	1.52	−0.03724	−0.43
HEADHH	0.7	−0.07853	−0.49	−0.20316	−0.97	0.048445	0.28
EDHHLD	4.4	0.009566	0.44	0.003561	0.12	0.010113	0.43
AGEHEAD	42.4	0.009402	1.80	0.016233	2.36*	−0.00115	−0.20
AGE	57.2	−0.01573	−10.52*	−0.00698	−3.61*	−0.01523	−9.11*
DUMSEX	0.5	−0.1084	−0.96	0.15204	1.03	−0.27286	−2.20*
MEANHTM	1.6	3.9074	3.35*	4.5712	2.98*	1.4387	1.12
FEMMAIN	727.1	0.000139	0.91	0.000011	0.06	0.000255	1.52
MALEMAIN	43.9	0.000288	0.26	0.002254	1.56	−0.00180	−1.47
DUMWATER	0.4	−0.05282	−0.41	0.18016	1.07	−0.2534	−1.82
DUMSAN	0.3	0.2525	1.83	0.14872	0.82	0.2125	1.41
DISVV	14.5	−0.02224	−2.68*	0.001876	0.17	−0.02882	−3.18*
SEASON2	0.3	0.57666	6.66*	0.26678	2.52*	0.47617	4.74*
SEASON3	0.3	0.55547	6.59*	0.30219	2.93*	0.40724	4.15*
SEASON4	0.2	0.48773	5.44*	0.52034	4.74*	0.16893	1.61
Constant		−6.8078	03.79*	−10.378	−4.39*	−0.37311	−0.19
R^2 (adjusted)		0.06		0.015		0.13	
F		6.7		5.4		10.8	
Sample (N)		1,181		1,181		1,158	

Notes: Variable definitions:

YC = Total consumption expenditure per capita per month;
PFFIJ = Proportion of area farmed by females independently and jointly;
DEPRATIO = Dependency ratio, <14,>60/14-60;
HEADHH = Sex of head of household: 1 = male, 0 = female;
EDHHLD = Education of household head, grades completed;
AGEHEAD = Age of household head in years;
AGE = Age in months;
DUMSEX = Sex: 1 = male, 0 = female;
MEANHTM = Mean height in meters of females 20 years and above;
FEMMAIN = Female annual labor hours spent in household maintenance;
MALEMAIN = Male annual labor hours spent in household maintenance;
DUMWATER = Availability of protected water: dummy = 1 is protected water;
DUMSAN = Availability of sanitation facilities: dummy = 1 with latrine;
DISVV = Distance to health services from village (kilometers);
SEASON2 = Season 2 dummy;
SEASON3 = Season 3 dummy; and
SEASON4 = Season 4 dummy.

*Significant at the .05 level.

with adoption, the share of women's crop ownership was found to decline, which may have neutralized the positive effect of income gains alone.

Household characteristics such as male or female headship did not have any impact on the nutritional status of children. However, age of the head of household was a positive factor, indicating that a three-generation extended household is likely to have a favorable effect on a child's nutrition. Holding these variables constant, increasing time spent by women in household maintenance activities has a positive effect on child nutrition variables (weight-for-height and weight-for-age). It is, however, not a statistically significant effect, in contrast to its role in household food consumption seen in the previous chapter. Analysis of women's work in Kenya has also suggested that it may not be a factor in variations in child nutrition (Rubin 1990). The proxy variable for mother's height is positive for nutrition status in the longer term.

Health-related variables all made important contributions to child nutrition. A shorter distance to health services helped improve weight-for-age and weight-for-height, suggesting that there are nutritional benefits from reducing the severity of illnesses, at least in the short term. Improved sanitation, on the other hand, has a long-term impact, with both height-for-age and weight-for-age showing improvement. The results of the improved water variable are somewhat puzzling. While their effect on the long-term height-for-age variable is positive, the impact on the short-term weight-for-height variable is negative and statistically significant. This suggests that a protected water source may have an adverse effect, even contributing to illness, if maintenance of the water source is poor.[48]

Older children are leaner than younger children, with significantly lower weight-for-height and weight-for-age, but there is some indication of catch-up in terms of height, which has a positive sign with age. The variable for sex of the child shows that girls are more likely to have a favorable weight-for-height ratio, and this is statistically significant, but boys are likely to be taller.

Seasonal variables are significant for all three indicators. While weight-for-age is significantly improved in each of the seasons after the February lean season measure of Round 1, weight-for-height improvements begin with Round 2 (pre- and early harvest) and continue into Round 3 (the postharvest period), but they are largest in Round 2. Height improvements are present in rounds 2, 3, and 4, but increase in size in the later rounds even when weight-for-height is no longer improving. This result illustrates the lagged height response to improvements in body weight of children during their growing years.

The results confirm that household income and intrahousehold income are both significant factors in improving child nutrition in the long run. The result for the effect of women's time spent in household maintenance activities suggests that this by itself is not a significant factor. While household income and women's intrahousehold income share are primarily longer-term predictors of child nutrition, women's time allocation in household maintenance activities is positive (but not statistically significant) for the shorter-term weight-for-height measure. The role of income, its allocation, and time spent in consumption support are postulated to influence the direct determinants of child nutrition, that is, food consumption and use of health services. Environmental and infrastructure variables also have the expected signs, with an improvement in access to health services and better sanitary conditions showing up as positive factors, confirming the role they play in disease prevention and control. The temporal link between short-term and long-term nutrition measures over the year is shown by the seasonal pattern of change, in which large weight-for-height increments occur immediately following the lean season and continue for about six months. Following the lean season, height gains are initially low, but, by

[48]Observations in Table 42 show a deterioration over the year in access to protected water. In low-adoption areas, 39 percent have protected water in season 1, but only 19 percent by season 4. The decline is also noticeable in high-adoption areas, but it is much smaller.

the sixth month, they have picked up sufficiently. For the remainder of the year, improvements occur only in height-for-age.

These results suggest why the adoption of hybrid maize, as with other agricultural technologies, has not shown clear-cut results in terms of improvements in child nutrition. To the extent that household incomes are improved, the result is positive. However, as was seen earlier in this report, income increments are not positively associated with adoption of hybrid maize for all farm sizes. Another factor that is found to be important in child nutrition is the share of income belonging to women. This declines with hybrid maize adoption, especially on larger farms, which tends to reduce the transfer of income increments to uses that benefit child nutrition.

10

CONCLUSIONS AND POLICY IMPLICATIONS

Since the mid-1980s, Zambia has faced severe economic pressures and the need for massive structural adjustment. The pace of reform has been slow and sporadic but appears to have picked up since the change of government following the popular elections in October 1991. The importance of technological change in agriculture, in general, and in maize production, in particular, is greater now than ever before. The reforms in grain marketing policy that are under way will unravel past policies that have promoted maize production over other crops. As a consequence of these past policies, maize production spread to all parts of the country by the mid-1980s. With liberalization of grain markets, the parts of the country that have produced maize even though they have poor access to markets will face lower incentive prices than the better-located areas, leading to a potential contraction in maize production.

Since maize is the main staple food crop for the Zambian population, the possibility of shifts in incentive prices for the crop creates a new urgency for rapid growth in maize productivity through technological change. It is likely that producers near the major markets on the line of rail, who tend to be in the commercial farming sector, long ago shifted to use of improved inputs. Therefore, improving their relative price advantage is unlikely to make much difference to their production practices and, hence, to total output. Eastern Province has some of the best agricultural land in the country; however, maize output could be substantially reduced, especially marketed production, given the province's distance from major urban centers. Under a liberalized market environment, technological change will be crucial to continued agricultural growth. Maize will remain an important crop because it is the major grain and because investments have already been made in adaptive research for varietal improvements. Although the potential for other crops will improve with removal of maize subsidies, they will face similar obstacles, such as lack of infrastructure.

This report suggests that there have been two major constraints to increasing maize productivity in the smallholder sector. First, even when farmers grow hybrid maize as a cash crop, they prefer to plant enough local maize to cover a major part of their food needs and they give local maize priority in labor allocation decisions. This reduces the potential for increasing yields through expansion of hybrid maize acreage. Explanations for farmers' reluctance to expand hybrid maize production include poor processing and storage characteristics of hybrids at the farm level, lack of incentive to improve on-farm storage capacity (this is likely to change with liberalization of grain markets), lack of village-level maize milling facilities, unavailability of appropriate seed varieties due to a poorly performing seed industry, and lack of adequate credit and marketing channels. Also, women are heavily involved in production of local maize for home consumption; it is possible that if they have greater involvement and training in hybrid maize cultivation, they will be more likely to incorporate it into the farming system as a food crop. Recently, new maize varieties have been released that have many locally desirable maize characteristics and, therefore, the potential for greater acceptance.

Incentives for better on-farm grain storage are likely to improve with liberalization of grain markets. These incentives were eroded by the state monopoly of maize marketing, which virtually eliminated seasonal maize price fluctuations, in contrast to the wide price fluctuations of other commodities in the region (Kumar 1984; Lele 1991). However, there is still a need to (1) assess the extent to which the recent changes in grain marketing and the availability of newer maize varieties are changing the process of incorporating high-yielding maize into the farming system, and (2) determine whether improvements in the seed industry and the seed distribution system as well as the credit, fertilizer, and extension systems are really reaching farmers. Public and private investments in infrastructure improvements that facilitate technological change are likely to be critical for incentives in the liberalized market environment in order for farmers in many parts of the country to increase their productivity. Such improvements will also be essential for the diversified and sustained growth in the rural economy necessary for food security improvements. For example, the availability of rural roads and markets facilitates investment in improved grain processing. Availability of small-scale hammer mills, for example, could substantially improve the ability of households to incorporate the higher-yielding hybrids into their diets by making them easier to process. These improvements would also encourage crop diversification beyond maize and open up off-farm employment opportunities.

The second major issue in the expansion of maize productivity in the smallholder sector is the finding that farmers cultivating less than 4 hectares of hybrid maize may be the most efficient producers, given the existing farming system and labor constraints. Above that size, additional land allocated to hybrid maize actually reduces household disposable income and appears to be sustained by an increasingly skewed intrahousehold distribution of income. These results are also reflected in different levels of improvement in food consumption with hybrid maize adoption on small versus large farms. At the household level, only small farms show significantly higher food and nutrient consumption when they produce hybrid maize; large farms actually have slightly lower per capita intake with hybrid maize adoption. Reduction in women's involvement in production is shown to be a key factor in this. Larger farms require more labor; if they cannot provide it, they tend to substitute purchased (subsidized) inputs for labor. This is an inefficient use of resources, which is reflected in smaller income gains and lower food consumption increments on the larger farms. These findings are consistent with the high supervision cost of labor on farms larger that those than can be managed by family, especially in labor-constrained farming systems like Zambia's (Binswanger, Deininger, and Feder forthcoming).

In the past, most of the agricultural development efforts were geared to reaching the larger farmers in the traditional sector. In Zambia, they were called "emergent" farmers and were especially targeted in agricultural development efforts in which increasing marketed production was an important goal. While capital-intensive technologies, especially use of mechanical traction, have been used on large commercial farms to overcome labor constraints, these have not been successful in the smallholder sector without additional subsidies. Results in this report support the need for approaches that are geared to smaller producers who are better able to respond to intensive production methods. Under a liberalized market environment for both inputs and agricultural products, innovative extension techniques with greater reliance on mass media may be appropriate to bring advice and information to the large number of smallholder farmers in the country, both men and women.

Adoption of hybrid maize is found to reduce women's income share and the relative value of their time, leading to changes in patterns of time and income allocation. These changes have implications for farm production efficiency and for improvements in family welfare. Overall, women had a high degree of involvement in crop production, both in decisionmaking and labor input. About half the farmed area was either independently or jointly managed by women. Women's share was highest for local maize and traditional cereals, like sorghum and millet, and lowest for hybrid maize. Measurement of actual farm economic transactions also showed that in hybrid maize-adopting households, women made fewer economic decisions related to crop production, and they obtained a smaller share of income from it. This is consistent with a reduction in women's relative returns to labor in these households. If women's access to information and inputs for hybrid maize influences their ability to manage the crop, then it is likely that efforts to provide women with access to these resources will increase the efficiency of its production. A great deal has been written by now on the need for better access by women to agricultural technologies and inputs and on the best approaches for providing it. Practical success in program design and implementation, however, has been negligible. Future breakthroughs will lie in the ability to develop participatory approaches in which women farmers can identify program components and delivery mechanisms that work. Often, even when programs are aimed at women, the intended benefits fail to reach them (von Braun, Puetz, and Webb 1989). Such top-down approaches fail to take into account the reality of women's constraints and needs. Thus it is imperative to include women's perspectives in designing extension programs that educate farmers on obtaining and using new inputs.

Hybrid maize adoption and higher incomes also change intrahousehold returns to labor and its allocations. When household income increases, women increase their time in household maintenance activities. However, when their own incomes rise, they reduce their work time in all activities, which suggests either that they wish to have more leisure time or that returns to work time have not risen sufficiently, or both. The idea that the time spent by women in generating income is reduced with rising household income is not new; it is a fairly widespread observation, even in rural areas (von Braun and Kennedy 1994). However, factors in the shift of women's time into household maintenance work have not been well documented. This report shows that this shift is likely to be due to the relatively greater improvement in men's returns to labor and the increasing demand for home consumption goods such as processed food, fuel, and water with rising incomes. Women's income gains, on the other hand, lead to a substitution of market goods for time in household maintenance.[49]

As with income and household food consumption, hybrid maize adoption has mixed results for child nutrition. There are fewer undernourished children under 10 years of age among the smaller adopting farms (defined as farm size equal to or less than the median farm size of adopters), compared with the larger farms. The small farms that have adopted hybrid maize are not only more efficient in generating net

[49]For example, taking grain to be milled versus processing it entirely at home.

income gains, but they also have a higher share of women's income, without the excessive work loads faced on large farms. The combined effects result in better levels of child nutrition among the smallholder adopters than in any other group.

Results indicate that while both women's income share and their time spent on household maintenance have significantly positive effects on household food consumption, women's income share has the larger impact, including improvements in child nutrition. For women, it is clear that there is no simple, costless trade-off in household welfare for a shift from earning returns to labor in the work force to spending increased time in household maintenance activities. However, the net positive returns from women's income and management in agricultural production are higher on balance and can be further strengthened by improved efficiency in time spent on household maintenance (through, for example, access to hammer mills for grain processing, improved water sources, promotion of fuelwood lots for communities, and educational programs). These findings support earlier observations on the significance of the production role of women for improvements in the productivity of hybrid maize, and they suggest that a reduction in women's income share and relative value of time are unlikely to be costless even though they end up spending more time in valuable household maintenance activities.

The results confirm that women's productivity and income should be promoted, and this applies both to farm and off-farm income sources. Like the need to provide inputs and resources to small farmers, improving women's access to productive resources will require innovative policy approaches. As suggested earlier, increased participation of women in the design and implementation of policy mechanisms is crucial to ensure that women receive the intended benefits. This report also illustrates that (1) households headed by women can be among the technological innovators once they overcome resource constraints, and (2) the majority of women farmers reside in households headed by men, in which both men and women participate in decisionmaking regarding agricultural production. Both groups of households face adverse efficiency, equity, and absolute welfare outcomes unless there are parallel improvements in the value of women's time with adoption of improved agricultural technologies. There may also be new opportunities for increased off-farm income generation for women that can be explored. In both farm and off-farm enterprise development, however, success will depend on the ability of women to obtain access to resources and technology along with skills and training.

Food consumption patterns in the area show a relatively well-balanced and diversified diet but one that is high in bulk and low in caloric density. Areas with a high degree of hybrid maize adoption have a generally better dietary intake (as measured by calories and proteins in the diet). While staple food consumption increased in high-adoption areas, dietary diversity was reduced due to more reliance on own-production and less on purchased foods. Because this decrease in diversity could lead to micronutrient deficiencies, it needs to be examined further. The emergence of regional differences also needs to be monitored and analyzed to make appropriate policy recommendations for correcting emerging imbalances.

The results indicate that increases in food consumption and income generation are interconnected. This is not surprising in view of the labor-constrained farming system and the importance of labor input in production in Zambia. In relatively food-scarce households, this is found to contribute to labor allocation patterns that parallel the seasons when food is more available. This suggests that in predominantly agricultural areas, such as rural Zambia, policies that augment food availability in seasons of scarcity may contribute to higher agricultural productivity and hence higher incomes in the area. Other measures that could facilitate seasonal food availability and consumption include improvements in rural grain storage and markets, seasonal savings and credit schemes oriented to meeting food consumption needs, and food-for-work programs for infrastructure or irrigation improvements that create income during slack periods.

Child nutrition in the long run (height-for-age) is found to improve with increasing household income, higher share of women's income, improvements in the sanitary environment, and access to health services. "Improved" water sources can actually be worse than traditional sources if they are not properly maintained. Shorter-term fluctuations in child nutrition or downturns, especially of a seasonal nature, tend to occur during periods when the work load in agriculture is high. These downturns can be prevented by adequate access to health services and provision of adequate time for child care and household maintenance activities. When food supplies are low, work loads in agriculture are heavy, and few other income sources exist, getting through the hungry season is a challenge every year, especially for children. At these times, the work load of women is a negative factor in child nutrition. If women are then able to reduce agricultural work to spend more time in household maintenance activities, it may prevent seasonal deterioration in child nutrition. However, other income sources will also be needed, especially those that can be drawn upon during such times.

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