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IRRIGATION TECHNOLOGY AND COMMERCIALIZATION OF RICE IN THE GAMBIA: EFFECTS ON INCOME AND NUTRITION

Joachim von Braun
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August 1989

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FOREWORD

With its focus on irrigation technology and commercialization of rice in West Africa, this study addresses the question of how agricultural growth in Sub-Saharan Africa may improve food security. Over the last few decades in Africa, rice has ranked second after maize among cereals that have contributed to the overall growth of cereal output. In West Africa, rice imports have grown rapidly during the last two decades. Future decisions on irrigation investments and technology choices will be of critical importance in view of numerous past failures and excessive costs of irrigation in Sub-Saharan Africa.

This research by Joachim von Braun, Detlev Puetz, and Patrick Webb is to be seen against the backdrop of policy priorities resulting from the earlier work of IFPRI and its collaborators on accelerating food production in Sub-Saharan Africa.

The study results highlight the measurable positive effect that incremental income in the hands of the poorest has on nutritional improvement. It is encouraging to learn that yield levels comparable to the highest yields in Asia can be obtained in irrigation schemes in Africa, but the issue of lowering irrigation costs remains a crucial one. In part, these currently high costs are due to the general lack of infrastructure in Africa. Another emphasis of the study is the identification of very high substitution effects between irrigated crops and rainfed crops because of swift labor movements between the crops.

The study comprehensively traces the nutritional effects of technological change in The Gambia via production, income, employment, and consumption effects in innovative ways. It stresses the need to consider cause and effect relationships in complex household economic systems. Having a multidisciplinary team of economists, anthropologists, and public health experts work on these issues has proven very useful.

A particularly noteworthy aspect of this study is the complex relationship between agricultural productivity and labor utilization. An increase in labor productivity may induce both fundamental changes in the intrahousehold system of division of labor and major shifts of labor between agriculture's subsectors. Emphasis is required in program design on breaking the labor bottlenecks in this environment under seasonal stress.

Among the important lessons of the study are that technological change is a key to improving food security at the household level in this West African environment, and that irrigated rice with appropriate technological considerations in the riverine areas can make a substantial contribution. To incorporate women farmers into the technologically driven modernization process, women must have access to the means that permit them to use the new technologies—especially access to inputs and credit. Food-security improvements in terms of reduced hunger are substantial and can be cost-effective with technological change, but health and sanitation constraints in environments with weak rural health services need to be alleviated jointly to reap maximum benefits from the agricultural commercialization process. The latter point confirms findings of comparable research by IFPRI in Guatemala and Kenya that health and sanitation services in rural areas have to move in tandem with the agricultural modernization process in order to reduce the nutrition problem along with the hunger problem.

John W. Mellor

Washington, D.C.
August 1989

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1

SUMMARY

Technological change in African agriculture is usually necessary, but not always sufficient, to achieve sustained increases in production. How can technical progress in a crop, and the resulting local growth in marketed surpluses of that crop (that is, the commercialization of traditional agriculture), be designed and complemented so as to improve the chances of African countries to (1) raise the aggregate output of crops, and (2) reduce poverty, improve food consumption, and advance nutrition, especially among vulnerable preschoolers?

This study examines such questions in the setting of a major technical improvement in rice production in a West African country. The study asks: To what extent does technical change raise production? Does such change encourage the diversion of labor from other activities into modern rice or into leisure as income rises? If extra production does materialize, does it increase income and consumption? If so, do the poor benefit from this? Does any such extra consumption affect adult and child nutrition? The links between production, income, consumption, and nutrition are explicitly established in the analysis.

The study focuses on a new rice irrigation project involving about 7,500 farmers in The Gambia. The study site was selected because households could be traced during and after the introduction of new rice production technology (mechanical pump irrigation and improved drainage for rainfed and tidal irrigation).

The empirical research is based on a detailed sample survey of 900 farmers in 10 villages. This sample includes both participants and nonparticipants in the irrigation project and covers the four major ethnic groups of the area, thereby providing a fair degree of representativeness for a wider part of the West African region, especially major parts of Senegal and Guinea. Account is taken of the complexity of production-consumption relationships in the large households that are typical of the region.

Production in the project takes place under fully water-controlled conditions (pump irrigation and drainage) that provide two crops per year, and also under partly water-controlled conditions (tidal irrigation or improved rainfed cultivation and drainage) that provide only one crop (in the wet season). Wet season yields in the fully water-controlled perimeters were 6.6 metric tons per crop per hectare in 1984 but dropped to 5.2 tons in 1985. In the same two periods, the partly water-controlled rice yielded 2.2 and 2.8 tons, respectively. Traditional rainfed rice (predominantly a women's crop grown in swamps) yielded 1.3 tons. Great variance in costs and net returns is observed between the technologies and between individual farmers using the same technology.

Average and marginal labor productivities are assessed in the context of the production system for the major crops. Average labor productivity (net returns per labor day) was highest for rice under pump irrigation (US$2.45), followed by coarse grains (US$1.50), groundnuts (US$1.45), rice in the partly water-controlled project fields (US$1.23), and traditional swamp rice (US$0.95).

Most farmers at the project location grow both irrigated rice and upland crops. The expansion of modern irrigation has pulled labor away from the upland crops, causing a loss of 531 calories in other crops for every 1,000 calories gained in rice production—a net gain of 47 percent.

Men's overall labor input to agriculture is reduced when the household has more land in the project. Women's labor input, on the other hand, remains more or less constant. Hired labor accounts for 25 percent of the work in the pump-irrigated plots. Since hired labor played only a marginal role in rice production before the project, this reflects an increased use of hired labor in rice as a phenomenon associated with commercialization.

There was a specific attempt in this program to ensure access to project land by women, the traditional rice producers. Formal land titles for plots were given to female farmers. Yet the results were not as planned. Women continue to control 91 percent of traditional swamp rice fields, and even 77 percent of the partly water-controlled fields, but they control only 10 percent of the pump-irrigated plots.

Less of the new rice crop is sold for cash than expected—12 percent of total production from pump irrigation and 7 percent from partly water-controlled land. This compares with women's traditionally grown swamp rice, of which 21 percent is sold. This pattern of women selling relatively more than men is explained by the different institutional arrangements under which the crops are grown. The high-technology rice in the project has largely become a communal food crop for the common household pot under the compound head's control, while women's traditional rice is a mixed private crop (partly grown for cash) and communal food crop.

Protecting and enhancing women's productive role in agriculture is an important objective in itself. It is also important as an indirect path toward nutritional improvement. The study finds, however, that this objective cannot be enforced through bureaucratic means (formal land titles), which have little relevance in the field.

Average annual per capita income in the study area was US$116 in 1985/86; agricultural income contributed 77.5 percent. Rice production in the project contributed 43.0 percent of income to the bottom income quartile (income per adult equivalent) versus 26.0 percent to the top quartile. The poor households thus benefit relatively more than do the upper-income groups in the area. At the sample average, the rice in the project increased real incomes by 13.0 percent per household.

An additional 10.0 percent of income leads to a 9.4 percent increase in food expenditures and a 4.8 percent increase in calorie consumption. The seasonal fluctuation in per capita calorie consumption is a problem of the poor and not of the total rural population. In the bottom income quartile, calorie consumption is 15.0 percent lower in the wet (hungry) season than in the dry season, but it remains constant and, indeed, sufficient in the top quartile. In the wet season, 49.0 percent of households in the bottom quartile consumed less than 80 percent of calorie requirements; only 2.0 percent of the top quartile fell below that level.

In the wet season, 35 percent of children under five years of age and 52 percent of those aged one to two years were found to be underweight. Lack of food, unclean water, and infectious diseases are identified as important determinants of nutritional status in multivariate analyses. Mothers' nutrition and health are considerably affected by seasonal work stress.

Household-level calorie consumption is a determining factor for differences in the nutritional status of children in the study area. A 10.0 percent increase in calorie availability per capita increases the weight-for-age indicator of nutritional status by 2.4 percent at sample means. This calorie elasticity of nutritional improvement is even higher in households with higher calorie deficiencies. To the extent that the new technology increased household income, and thereby calorie consumption, and to the extent that mothers' seasonal stress was reduced, the nutritional status of children and women has improved.

The study implies a set of policy conclusions for improved technology utilization, food security, and nutrition. A more broad-based policy and program emphasis on improvements in rural infrastructure, agricultural input delivery systems, and labor-saving technology for the peak season is called for rather than a focus on a single crop.

Rice irrigation shows promising potential in the study area, but technology choice and project design issues are complex. Specific suggestions related to choice of rice production technologies demonstrate opportunities for cutting costs in the respective technologies.

Measures are proposed to protect and enhance women's productive role in agriculture; for example, women's role as cash croppers and their lack of credit require more attention.

From a food security perspective, a wide distribution of small irrigated rice plots is needed across households and village communities in the area to reduce the adverse effects of seasonality and consecutive drought years on consumption. Such scattered distribution of the highly productive irrigated land results, however, in fluctuating yields, since in years of good rainfall labor is allocated more heavily to upland farming, while in drought years labor shifts more to the irrigated fields. Thus, good rainfall years appear bad for production in irrigated farming surrounded by upland farming with large year-to-year fluctuations of labor productivity. In the absence of well-developed rural financial markets, the food-security benefit of scattered land distribution (rather than creation of larger specialized rice farms) should be an important consideration despite the instability it induces in irrigation projects and the related project management burdens.

Finally, the study suggests that efforts to solve the nutrition problem can be furthered through more effective rural health services and sanitation (that is, drinking water) at the community level. The interactions between food shortage and morbidity, which establish the high prevalence of malnutrition in this study area, cannot be dealt with effectively from the food supply side only. The nature of the nutrition problem requires a strong focus on women (mothers) rather than on young children alone.

2

SCOPE OF THE STUDY AND CONCEPTUAL FRAMEWORK

An increasing number of low-income countries, especially in Africa, are facing crucial strategic decisions on how to cope with short- and long-term food-security problems. At the core of these strategic decisions is the appropriate choice of policies to promote technological change and increased market integration of crop production. This choice has to be addressed both for food crops for local consumption and for food and nonfood crops for export. This study is part of a larger ongoing effort at IFPRI that is aimed at improving understanding of the effects of technological change and commercialization at the household level.[1] The objective of this research is to provide planners and policymakers with insights that will help guide program design and policies that affect the process of technological change and commercialization in traditional agriculture. With such information at hand, potentially adverse effects of change on the consumption and nutrition of the poor may be avoided and the benefits enhanced.

In a broader sense, this study, with its focus on rice and irrigation, ties in with IFPRI's research (between 1979 and 1985) on rice policy in Southeast Asia and comprehensive studies on technological change of rice in Bangladesh (Hossain 1988). It also relates directly to IFPRI's research on changing consumption and production patterns in the Sahel, that is, the relative shift away from coarse grains (Delgado and Miller 1985), and evolves out of research priorities identified in IFPRI's collaborative efforts in Africa (Mellor, Delgado, and Blackie 1987).

The main research questions of this study are (1) How do technological change and commercialization affect resource use, income, consumption, and nutrition? (2) How can programs and policies for technological change in agriculture be designed in order to enhance the positive income effects of market integration and to cope with potentially adverse welfare effects? (3) Does the process of commercialization have adverse effects on the consumption and nutrition of selected groups of households or individuals within households? and (4) How can the rural poor, especially female farmers, be effectively integrated into the commercialization process? These general questions are tailored in this study to a case study in West Africa in which groundnuts are the principal cash crop and pump-irrigated rice production is a driving force of technological change and commercialization.

A few words are in order here to define *technological change* and *commercialization.* Technological change is understood as increased aggregate factor productivity, that is, the same output produced with fewer inputs or more output produced with the same amount of inputs, though the nature and composition of the inputs may be different.

Increased commercialization may occur with or without technological change. However, technological change rarely occurs without commercialization—at least on the factor-input side of production (seed, fertilizer, irrigation, hired labor), if not on the product-output side, leading to an absolute or relative expansion of marketed surplus. It should be underscored that in considering commercialization in this setting, the

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[1] Studies following a similar approach have been undertaken by IFPRI in Kenya, the Philippines, Rwanda, and Guatemala.

study is not dealing with a typical situation that involves a change in crop mix, away from food crops for home consumption toward new crops grown primarily for sale. In this instance, the project under consideration introduced new technology for improved production of a single crop (rice) that was already grown and marketed locally to a limited extent.

The project was aimed at increased output and increased market integration through technological change in rice. Various irrigation technologies were introduced, comprising different packages of inputs and degrees of water control. In this study case, technological change and increased commercialization are closely intertwined, which suggests the need to carefully address costs of production along with expansion in output.

The relationships between technological change in food production, markets, and income and the effects of such change on food consumption and nutrition are complex. The more intricate the household organization and its production arrangements, the less straightforward these relationships are. However, if the food security of the rural poor is to be effectively improved and sustained, such links need to be thoroughly understood. Furthermore, a complete assessment of the multifarious effects of technological change requires an integrated view of households and of the markets in which they interact.

This study deals with the local- and household-level effects of technological change and commercialization in rice production. An attempt is made to identify and quantify the effects of such change in the spheres of employment, time allocation, labor productivity, income, and marketed surplus, and to determine how these affect consumption and nutrition. The special characteristic of the study is that the effects of change in production and marketing are traced through to the relevant consumption and nutrition effects. Considerable research exists covering individual aspects of the chain of events depicted in Figure 1,[2] but so far very little empirical research has attempted to trace the interconnections of the major elements of this chain, especially in Africa.

While the study takes an integrative view of household production, consumption, and marketing decisions, it refrains from building the analysis on an integrated household model,[3] but rather conceptualizes the set of problems in terms of partial analyses within the framework of Figure 1. This route was chosen because the complexities of numerous structural relationships in the household production-consumption system would have been lost at the necessarily higher level of aggregation required for a closed household model. Also, the largely cross-sectional nature of the data suggests a cautious approach. There are inherent problems with unobserved latent variables and lack of independence among observations in a cross section. It is desirable to invest in building more longitudinal data sets in the long run to avoid these problems.

Figure 1 shows the conceptual framework followed in the analysis, at the same time providing an outline of the main themes covered by the report. The effects of technological change and commercialization on nutrition are mediated through (1) the nature of the new technology, (2) the adoption process and its production and income effects (and the resulting effects on employment and time allocation), (3) expenditure patterns and food consumption (which may not be uniform among the individuals of a household), and (4) the health environment that impinges on nutrition. The latter may be affected by expenditures on health and sanitation and by time-allocation effects of technology adoption "upstream" in the diagram (for example, mother's time allocation) or changes in the physical environment.

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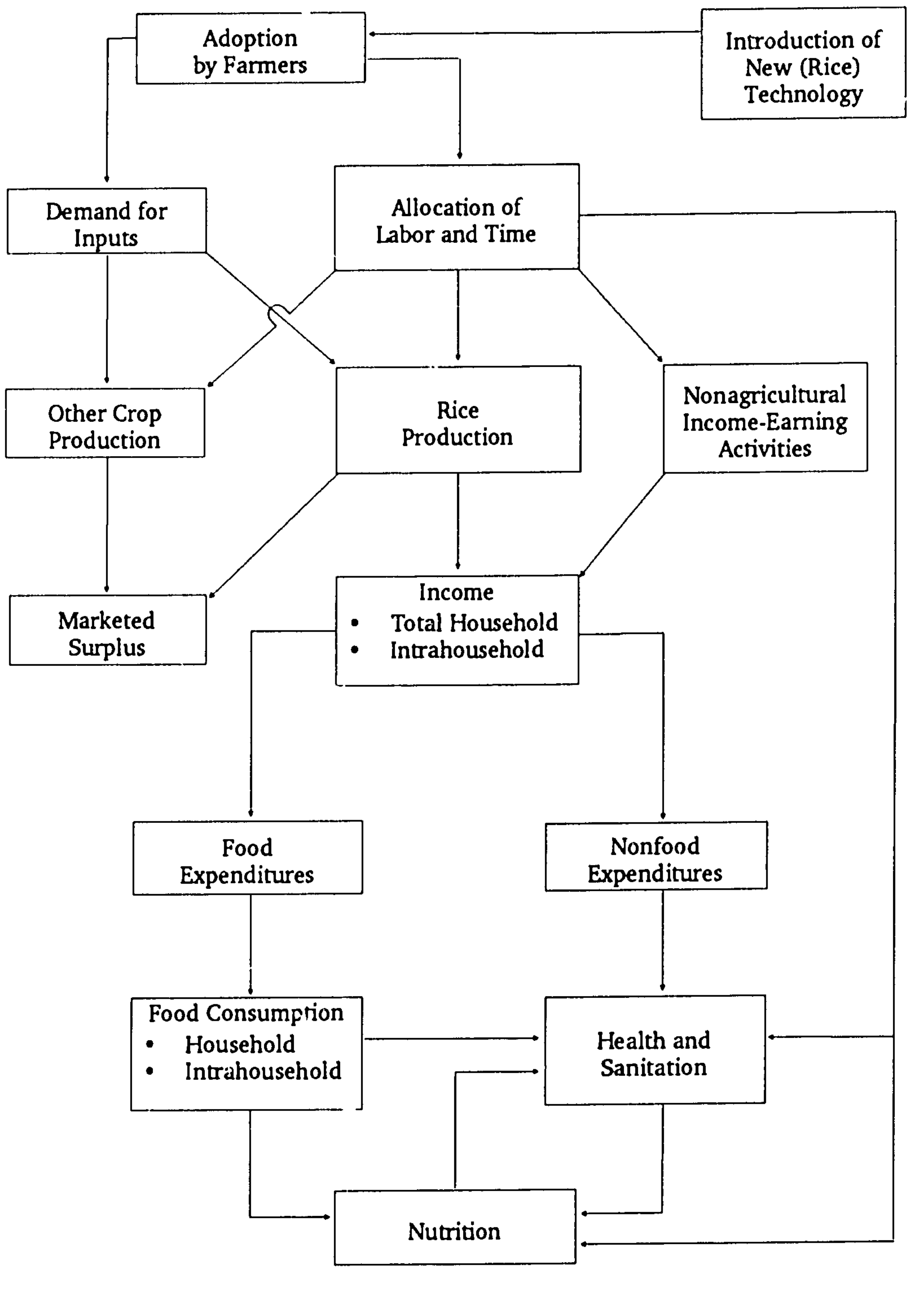
[2] A review of literature on the issue is provided in von Braun and Kennedy (1986).

[3] On household models and their potentials for policy analysis, see Singh, Squire, and Strauss (1986).

Figure 1—Conceptual framework for analysis of household-level effects of new technology and commercialization



A better understanding of these critical relationships is essential to an identification of efficient modes of intervention designed to improve nutrition. The adoption of a given package of new technologies may involve certain trade-offs; for example, it may raise income but impose negative time constraints on child care. An early identification of such trade-offs and the design of corrective program components are essential to avoid short-term adverse effects of technological change on the poor.

The main methodological steps in the study, following the conceptual framework depicted in Figure 1, are the model analysis on access to new rice technology and adoption, the labor allocation model, the production function analysis, the marketed surplus analysis, the income earnings model, the food (energy) consumption model, and the models explaining nutritional status in the context of the health situation.

These models are designed so that the explained variables "upstream" in the diagram become explanatory variables "downstream" in the chain from technology to production to income to consumption to nutrition. But some feedback mechanisms should also be expected to work; for instance, better nutrition improving labor productivity. However, the intricacies of interactions in the household production system on the ground make the actual approach more complex than is depicted in the simplified diagram.

A brief sketch of the rationale and flow of analysis will be given here at the outset. Details follow in the respective chapters. The model sketches below are simplified and do not provide the specifics of variable definitions, precise units of observation, or time lags, but rather an overview on the flow of analysis and the conceptualization of exogenous and endogenous relationships in this analysis.

The introduction of new rice technology is treated as exogenous in this setting, but the degree of access to it by household units (compounds) is endogenous. The amount of land under new rice technology acquired by the household unit (HHACC) is hypothesized to be a function of location of village in project area (LOCATION), ethnicity (ETHNIC), demographics of household (HHDEMO), household status in local hierarchies (HHSTAT), and household wealth (WEALTH):

$$HHACC = f(LOCATION, ETHNIC, HHDEMO, HHSTAT, WEALTH). \qquad (1)$$

This research, as well as the project around which it centers, is particularly concerned with the access of women—the traditional rice growers in the area—to the new rice technology. The probability of whether or not an individual woman within a household obtained access to land in the project (WOMACC; 1 or 0) is then hypothesized to be determined by the woman's demographic (WOMDEMO) and status characteristics (WOMSTAT) and by the degree of access of the household as a whole (HHACC, as dealt with in equation (1):

$$WOMACC = f(WOMDEMO, WOMSTAT, HHACC). \qquad (2)$$

Introduction of new technology in one crop may substantially affect allocation of scarce resources to that crop and thereby reduce resource allocation to other crops. The focus is especially on the (re)allocation of labor (LABOR) by crop (j) as a consequence of access to new rice land (HHACC), because the new rice technology requires a lot of incremental labor input. Also included in this analysis of labor input is a set of variables depicting production conditions (PRODCON), labor force structures (LABSTRUC), and capital stocks (CAPITAL):

$$LABOR_j = f(PRODCON, LABSTRUC, CAPITAL, HHACC). \qquad (3)$$

On the basis of crop-specific production functions (equation [4] below), whose main purpose is to estimate marginal labor productivities in this analysis, marginal output effects are derived from the estimated changes in labor allocation as a consequence of technological change in rice. The production functions for crops (j) consider labor input ($LABOR_j$), land and land characteristics ($LAND_j$, LANDCH), fertilizer use ($FERT_j$), technology use, such as appliances ($TECHNO_j$), and institutional arrangements under which the respective crop is grown, such as individual or communally grown crop ($INSTIT_j$), to depict the technical input-output relations in production ($OUTPUT_j$):

$$OUTPUT_j = f(LABOR_j,\ LAND_j,\ LANDCH,\ FERT_j,\ TECHNO_j,\ INSTIT_j). \quad (4)$$

Following the production analysis, the effects of change in output level and output composition are traced to their income and marketed surplus effects. The marketed surplus analysis focuses on the marketed outputs of cereals ($OUTPUTMA_j$), and attempts to explain these by the cereal production (CERPROD), prices (PRICE), income levels (INCOME), household demographics (HHDEMO), structure of crop composition along gender lines (WOMCER), and market-related infrastructure variables (INFRA):

$$OUTPUTMA_j = f(CERPROD,\ INCOME,\ PRICE,\ HHDEMO,\ INFRA). \quad (5)$$

In assessing the net income effects of technological change in agriculture at the household level, not only should the substitution effects in agricultural production be traced, but also those between farm and nonfarm income-earning activities. This is done in the context of an income-earning model in which income per capita (INCOME) is explained by upland crop-related agricultural capital (tools) and livestock capital (AGCAPITAL), human capital-related variables (HUCAPITAL), household demographics (HHDEMO), ethnicity (ETHNIC), and access to the new rice land (HHACC):

$$INCOME = f(AGCAPITAL,\ HUCAPITAL,\ HHDEMO,\ ETHNIC,\ HHACC). \quad (6)$$

The effects of changes in total budget availability (cash and in-kind) on spending patterns of households are then analyzed, and the effects on basic food consumption (calories) in the two main seasons of the year are modeled in greater detail. The conventional approaches of demand analysis are followed, enriched by structural variables that are determined by the local situation concerning food-consumption decision-making in the complex and large household units. Increased income is expected to raise food energy consumption per adult-equivalent person (CALORIE) but decreasingly so at the margin. The income effects are subject to the price situation (PRICE),[4] given a certain composition of household (HHDEMO), nature of the income stream (cash share [CASHSH]), and income control in the household unit (women's share [WOMCON]):

$$CALORIE = f(INCOME,\ PRICE,\ HHDEMO,\ CASHSH,\ WOMCON). \quad (7)$$

Finally, the effects of food consumption (CALORIE) are traced to the nutritional status of children and women (NUTSTAT). Of course, numerous interweaving factors,

[4] The role and potentially endogenous characteristics of consumer purchase prices in this model (equation [7]) and of producer sales prices (see equation [5]) due to seasonal variations are to be reviewed and are discussed in the respective sections of the report.

in addition to household-level food energy consumption (per adult equivalent), determine the nutritional status of children as quantified by anthropometric measures. Child-feeding practices, children's demographics (CHDEMO), household demographics that are important for the child-care environment (HHDEMO), the health record of child and mother (HEALTH), and the sanitation environment (SANIT) are most relevant. Also tested is whether increased access to new rice land with the new production technology had an additional effect on nutritional status besides those explanatory factors:

$$\text{NUTSTAT} = f(\text{CALORIE, CHDEMO, HHDEMO, HEALTH, SANIT, HHACC}). \quad (8)$$

The research was undertaken around the Jahally-Pacharr Smallholder Rice Project that is described in Chapter 4. The analysis is based on a series of sample surveys in 10 villages randomly selected from baseline information and 168 households (compounds) selected randomly in these villages. In some instances, these compounds are very large (up to 80 persons) and are subdivided into separate subunits of decisionmaking for production and consumption management. Taking this into account, there were 214 household units in the survey (for details on sampling, see the Appendix).

The main objective of the sample selection was to identify households that are, first, representative of the participants of the rice project and, second, involved in it to different degrees, thus providing the opportunity for a cross-sectional analysis of the project's effects on income and nutritional status. Since project land was distributed to villages according to traditional tilling rights in the swamps, a fairly large variation in plot size per capita is apparent for households between, and even within, different villages.

3

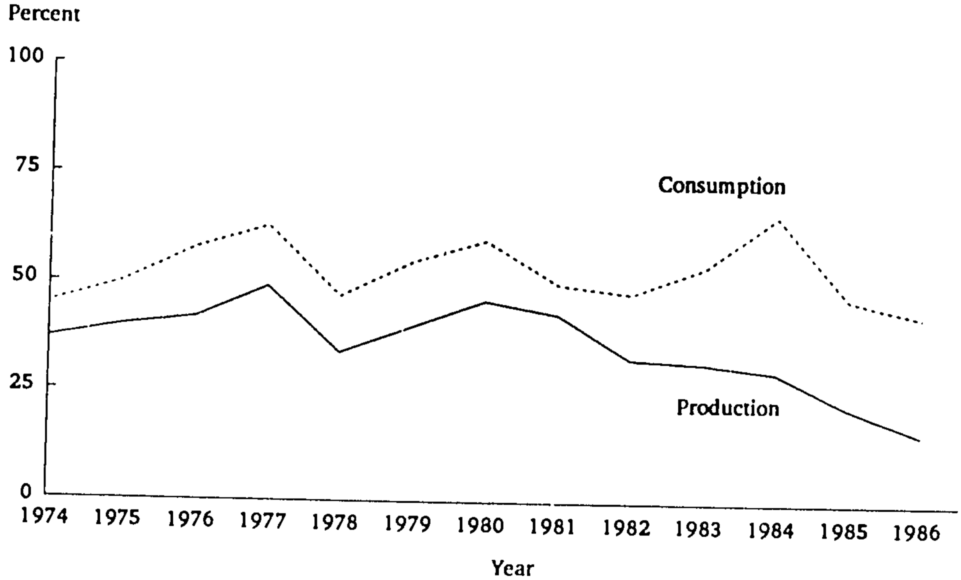
THE STUDY AREA AND ITS COMMERCIALIZATION THROUGH AGRICULTURAL PROGRAMS

The share of rice in total cereal consumption is traditionally high in The Gambia compared with neighboring West African countries. But domestic production in The Gambia has not kept pace with consumption growth, and the share of rice production in total cereals has declined, leaving a widening import gap (Figure 2). Better understanding of microlevel production relationships in the cereals sector and of rural consumption patterns and their determinants is required to design policies to cope with this import gap. This study contributes to the closing of related research gaps.[5]

Agriculture in the Study Area

The study area is located 300 kilometers east of Banjul on the south bank of the Gambia River (Figure 3). Population density is roughly 57 people per square kilometer. The area is inhabited by four different ethnic groups (Mandinka, Wolof, Fula, and Serahuli). Their villages range in size from 50 to more than 2,000 inhabitants, while their households have from 1 to over 80 people (the national average is 16). The

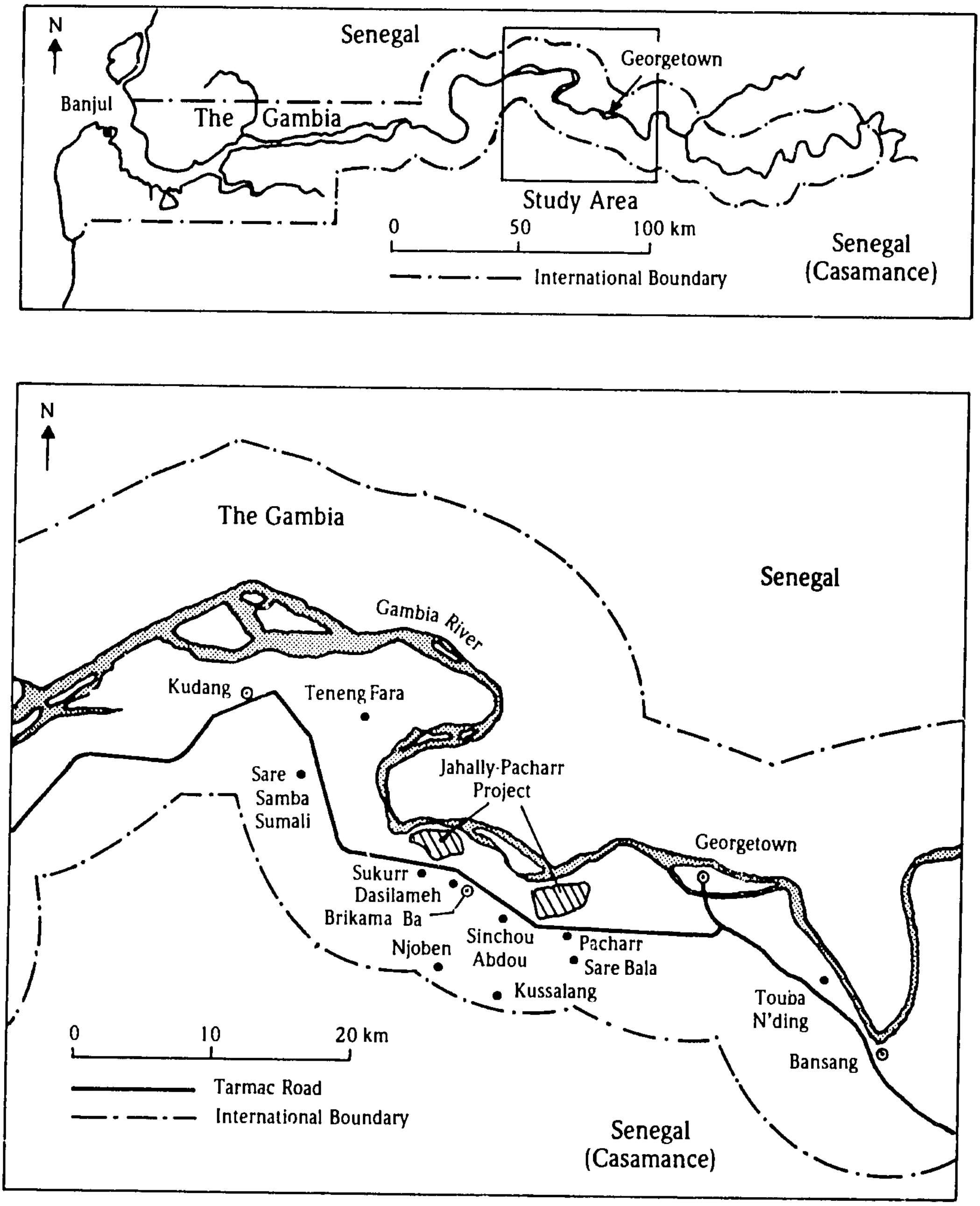
Figure 2—Share of rice in total cereal production and consumption in The Gambia, 1974-86



Source: Ken Johm, "National Production and Consumption Trends and Their Implications," in *Policy Issues for Rice Development in The Gambia*, ed. Sambou Kinteh and Joachim von Braun (Washington, D.C.: International Food Policy Research Institute, 1988).

[5] A larger research effort on these issues is ongoing at IFPRI for the Sahel countries.

Figure 3—Map of the study area



Note: Survey villages are indicated with a black dot. Small towns in the area are shown with a circled dot.

population is almost entirely Muslim. Agriculture in this area is dominated by the seasonality of rainfall and the related cropping season from July to December. Groundnuts—the traditional and principal cash crop—cover almost 48 percent of the upland cultivated area in the sample villages (Table 1).[6] The support system for groundnuts includes fertilizer credit, seed-improvement programs, and marketing arrangements. A number of other upland crops have also been promoted in the study area, but on a more minor scale. For example, a program promoting production of cotton (the secondary cash crop) was recently initiated with a subsidized input package. A small maize improvement scheme is also active in some of the villages in the study area. However, millet, the most important upland cereal, has largely been neglected.

This is in contrast to rice, which has been given the most support of all the staple foods, especially through irrigation schemes set up by the Taiwanese and the World Bank in the late 1960s and 1970s. Most of these schemes, however, have deteriorated, and they played only a minor role by the time the irrigation project that forms the focus of the present study was established in 1983/84. This project, the Jahally-Pacharr Smallholder Rice Project, has been the single most important factor in transforming agriculture in this area. A description of the project in the context of earlier rice projects is given in Chapter 4.

The commercialization process in the study area is not limited to groundnuts or to the influential rice project, but these, along with the smaller initiatives (cotton, maize),

Table 1—Shares of land area cultivated, by major crops, wet season 1985

Crop	Gambia Total	MacCarthy Island Division	Sample Villages[a] Upland Villages	Sample Villages[a] Lowland Villages
		(percent)		
Fully water-controlled rice in project[b]	0.3	1.0	2.7	10.0
Partly water-controlled rice in project[c]	0.3	1.0	1.9	7.0
Old irrigated rice schemes[d]	0.4	1.0	...	...
Swamp rice	10.0	13.0	1.0	18.0
Early millet	20.0	27.0	32.6	16.0
Late millet	9.0	1.0	0.7	2.0
Sorghum	5.0	5.0	3.9	5.0
Maize	8.0	9.0	7.0	10.0
Groundnuts	46.0	42.0	47.6	27.0
Cotton	1.0	1.0	2.6	5.0
Total	100.0	100.0[e]	100.0	100.0

Sources: Data for the Gambia total and MacCarthy Island Division are from The Gambia, *1986/1987 Agricultural Sample Survey Report* (Banjul: Planning, Programming, and Monitoring Unit, 1987); data for the sample villages are from the 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

[a] Upland villages in the sample are Njoben, Sinchou Abdou, Kussalang, Sukurr, and Sare Bala; the other villages are in the lowlands (see Appendix Table 57).

[b] These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

[c] These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

[d] These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.

[e] Parts do not add to total because of rounding.

[6] Besides being commonly known as a cash crop, groundnuts are an important food crop that provides a substantial share of the calorie and protein consumption requirements of the rural population.

drive the process. In addition, farming activities in livestock and vegetable production, as well as activities in the nonfarm income-earning arena (both inside and outside of the area, including resultant remittances) play a significant role in the overall market integration of the region under consideration.

Population and Infrastructure Characteristics

The population of the study area is relatively young. It was estimated that 43 percent were under 15 years old and barely 6 percent were over 60 years old.[7] The overall sex ratio was 0.965 but this included large fluctuations within the age groups. Sixty-four percent of women aged 15-19 were married, compared with only 4 percent of men. A sample of women aged 40-59 reported having had an average of 7.2 live births of which, on average, four children were still alive.[8]

The majority of farmers involved in the study area belong to one of the four principal ethnic groups that inhabit the region: the Mandinka, Wolof, Fula (also known as Peul or Fulani), and Serahuli (also known as Sarakole). Although the study site is located entirely in The Gambia, the coverage of the various ethnic groups gives this study a substantial degree of representativeness for household systems in West Africa, since the four groups are widely spread and significant throughout this part of the region (Figure 4).

Long-standing cooperation and a marked absence of ethnically based rivalry or animosity have led to all four groups living peaceably side by side in neighboring villages or even within the same village. However, there are a number of distinctions between certain types of villages.

Upland and Lowland Villages

The first distinction to be drawn between villages is that of geographical location, which partially dictates the types of crops that can be grown at a given site. Gambian villages take the form of nuclear settlements. The land to which each village lays claim forms a band of varying width around the inhabited core. This band is not necessarily continuous or concentric, but is like a mosaic of fields scattered at various distances around the concentration of dwellings.

Depending on the village's location, this land is made up of either sandy detrital sediment of relatively low chemical fertility (upland soils) or more fertile hydromorphic soils located closer to the banks of the Gambia River and its tributaries (lowland soils) (Dunsmore et al. 1976). As a result of these soil characteristics, the agriculture of the upland villages traditionally leans toward upland cereal crops and livestock husbandry, while the lowland villages, although they have access to both types of land, traditionally place a much greater stress on rice.

While the distinction between upland and lowland villages should not be used too rigidly (because no place in The Gambia is more than 20 kilometers from the river), this is a useful division that will be referred to repeatedly in the analysis. Lowland villages can generally be equated with "traditional rice tillers" status (allotting an average of 18 percent of their total land area to swamp rice), while upland villages

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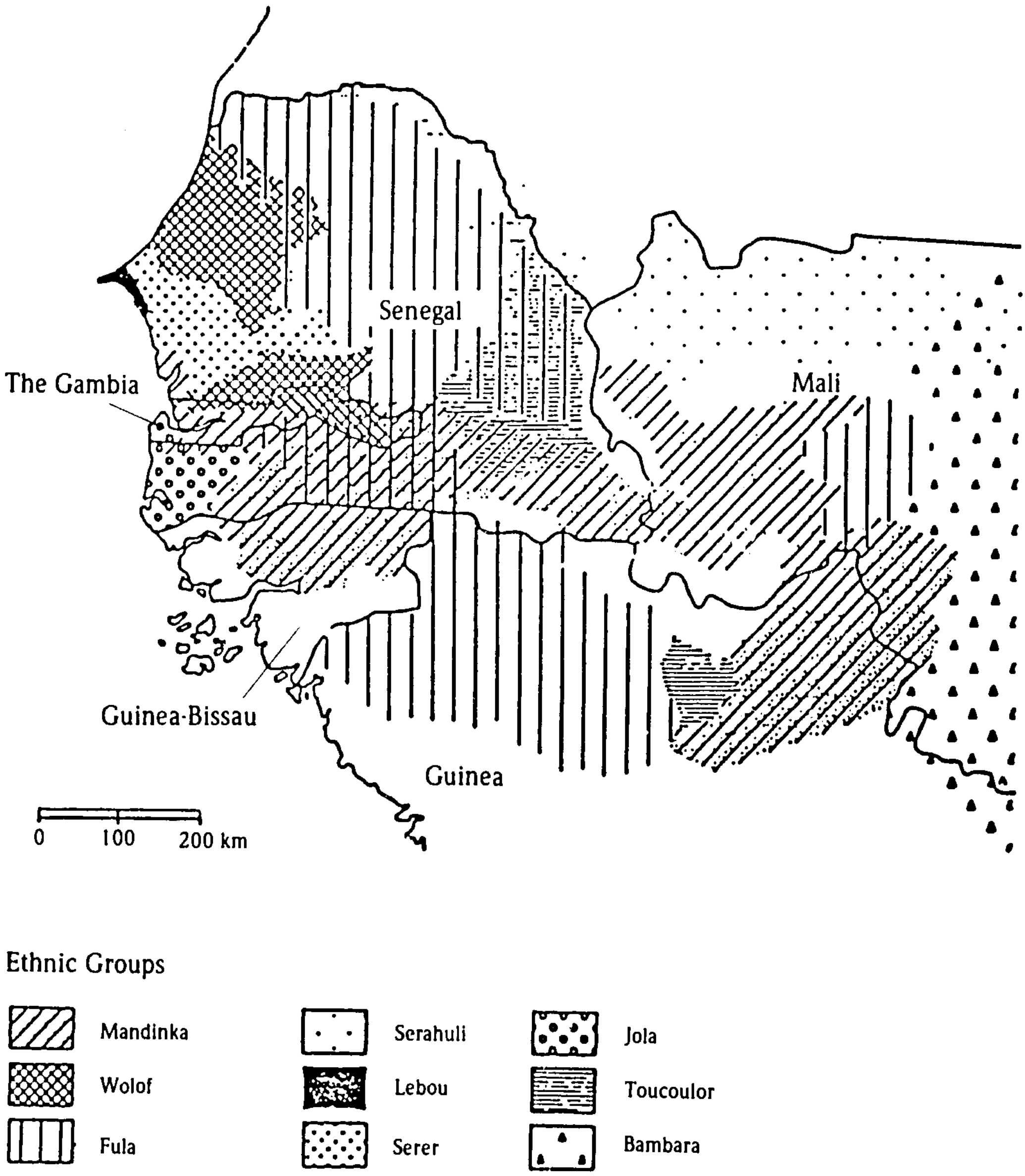
[7] Round 1 data for those present.

[8] The sample consisted of all mothers or caretakers of children under 10 years of age.

Figure 4—Distribution of major ethnolinguistic groups in The Gambia and neighboring countries



Source: Kenneth Swindell, *Farm Labour* (Cambridge: Cambridge University Press, 1985).

have generally turned to rice production only in recent years and allocate only 1 percent of their land to swamp rice (see Table 1).[9]

Ethnicity, Size, and Growth

The second major distinction to be drawn between the 10 sample villages is their ethnic and historical background. As shown in Table 2, the sample includes a mixture of ethnicities in both the upland and lowland villages. The two villages not involved in the irrigation project are Mandinka. Not every village is ethnically homogeneous, however, and the ethnic label attached to each village refers to the predominant group of inhabitants.

Table 2 shows that two of the sample villages (one Fula and one Mandinka) are at least 100 years old. Another four are over 50 years old, but the remaining four have been founded since the late 1950s. Sinchou Abdou, the newest village, was settled in 1981 as a direct consequence of the Jahally-Pacharr project: the present village chief had suffered poor crops for several years as a result of drought and decided to move when he heard about the forthcoming irrigation scheme.

Sinchou Abdou was established by Gambians moving from one site within The Gambia to another. Yet not all of the sample villages have such origins: two were founded by migrants from Guinea Bissau, one is of Guinean origin, and two were settled by immigrants from Senegal. The 10 villages also show considerable diversity in size and in their recent rates of growth. During 1975-85, Pacharr expanded the

Table 2—Ethnic and historical characteristics of the sample villages

Village	Ethnicity[a]	Approximate Age of Village	Founders' Country of Origin[b]	Number of Compounds in 1986	Population	Change in Number of Compounds 1975-85
		(years)				(percent)
Upland villages						
Kussalang	Fula	100	Guinea	18	200	0
Njoben	Wolof	60	Senegal	50	1,200	+52
Sare Bala	Fula	17	Gambia	7	90	+17
Sukurr	Serahuli	27	Gambia	10	200	0
Lowland villages						
Dasilameh	Mandinka	80	Guinea Bissau	50	450	+56
Pacharr	Mandinka	100	Guinea Bissau	59	750	+136
Sinchou Abdou	Fula	5	Gambia	15	150	c
Sare Samba Sumali	Fula	30	Gambia	16	130	+7
Nonproject villages[d]						
Teneng Fara	Mandinka	80	Senegal	12	140	+50
Touba N'ding	Mandinka	60	Gambia	12	140	-20

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.
[a] Few villages are ethnically homogeneous; this refers to the dominant group.
[b] Country from which the village founders migrated to establish their present home.
[c] Village founded in 1981.
[d] Not involved in Jahally-Pacharr Smallholder Rice Project.

[9] Table 1 shows that upland villages have a higher percentage of their total land in the form of project tidal-irrigated land than do the lowland villages. This is because the lowland villages (being traditional rice tillers) have priority for the best project land (pump-irrigated), leaving the lower-yielding tidal land to the upland farmers.

most rapidly (+136 percent), followed by Dasilameh (+56 percent), and Njoben (+52 percent). In other words, the three largest villages in the sample were also the fastest-growing villages during the decade preceding the study. Two of the upland villages (Kussalang and Sukurr) exhibit zero growth rate for this period, and only one village, Touba N'ding (outside the area of the rice project), shows a negative growth rate.

Services and Infrastructure

The next area of differentiation between villages relates to their access to infrastructure and services. Five of the sample villages are located less than 1 kilometer from the main tarmac road that runs the length of the country from Banjul to Bassé. These five villages are also only 5 kilometers or less from the project site. The remaining three villages involved in the project are located between 3 and 8 kilometers from the road, which places them 6-11 kilometers from the project rice fields (Figure 3).

Only one of the sample communities, Njoben, is served by a primary school in the village itself. Children in the other villages have to walk sometimes considerable distances each day to the nearest state-run school. Similarly, only one village, Pacharr, has a daily market within its confines. The other nine villages are located between 2 and 8 kilometers from such a market. Njoben, one of the villages farthest away from a daily market, compensates by having four small shops that sell durable commodities such as matches, kerosene, and batteries.

In addition to daily markets, a much larger market (attracting traders from as far as Banjul and Kaolack in Senegal) moves up and down the country each week. Villagers from Teneng Fara and Sare Samba Sumali visit it when it stops in Kudang. The inhabitants of Touba N'ding attend the market when it reaches Bansang. And all the other communities are within reach of the Brikama Ba stop.

In terms of health facilities, the only clinics providing rudimentary curative medicine are at Brikama Ba, Bansang, and Kudang (all on the tarmac road). Dasilameh's inhabitants are fortunate in living less than 1 kilometer from the Brikama Ba clinic. However, the other project-involved villages are also served by this one clinic, and their access to and use of its facilities are limited by distance (up to 20 kilometers in the case of Kussalang).

Every village has at least one "clean" well that is used as the principal source of drinking water for the community. Pacharr is unusual in having 17 such wells. A water analysis was carried out in all the sample villages in the dry season to discern whether there were major differences in quality that might affect the health of their inhabitants. The water analysis was conducted by quality control officers of the Ministry of Water Resources under contract with IFPRI. They took three samples from the main well in each village during the first week of September 1986, and carried out a coli count on site. The results indicate that Dasilameh, Sukurr, and Pacharr all enjoy relatively unpolluted water sources, while the other villages have access to less-clean water as measured by coli count. The significance of this factor for nutritional status of children is tested in the multiple regression analyses later in this paper and shows as significant.

Nonfarm Employment and "Strange Farmers"

A final set of distinctions may be drawn between the sample villages on the grounds of nonfarm activities and the functioning of local capital markets. Nonfarm income-earning activities, such as thatching, potting, and smithing, are found in all the villages. In some cases, there is only a handful of craft workers in a community. Kussalang, for instance, contains only three, and Sare Bala and Teneng Fara have only four each. Yet in the larger communities the number of craftspeople rises to a dozen or more. Sukurr is a special case; although only a small village, it has 24 craft workers among its farmers.

This is because two large households in Sukurr are traditional goldsmithing families and all the sons learn the art of smithing, while all the daughters learn the art of potting (a traditional association of the two skills by sex).

The same variation can be seen in the numbers of *marabouts* and "Strange Farmers" in each village. *Marabouts* are religious instructors who earn an income from teaching Koranic studies and from making magical charms. The new village of Sinchou Abdou has no *marabouts* yet among its inhabitants, in contrast with Dasilameh and Njoben, which have seven and eight, respectively. Strange Farmers are migrant workers who live in a village for one or more seasons, earning the right to grow a cash crop by exchanging their labor with a host for land and lodgings.[10] Such agricultural migrants are attracted to the communities with the most "surplus" land, the best farm tools, and the best infrastructure. Pacharr and Njoben, for instance, had 50 and 61 Strange Farmers, respectively.

Functioning of the Economy at Village and Compound Levels

Interactions within the Village

Each village comprises an amalgamation of households, generally referred to as compounds, that are clustered around a central point usually occupied by a silk cotton tree, a well, and a shady meeting place.

There are strong village hierarchies defined by lineage status (a form of caste system whereby former slave-owning compounds rank at the top of a status pyramid, followed by village-founding compounds, free compounds, artisan compounds, and finally, ex-slave compounds) and by duration of residence in the village (Haswell 1953, Dey 1982). At this level, interpersonal relations are controlled by the village chief and council of elders.

Differences in approach to control of the village are manifest in a number of aspects of village organization. For example, to help poor or sick farmers, all 10 sample villages arrange communal work groups to which every compound is expected to send a representative. However, some villages gather for such communal work more often than others: Dasilameh reported 48 such engagements a year. Touba N'ding organizes such groups roughly 24 times a year. Njoben, although a substantially larger village than Touba N'ding, calls the communal work group together only 4 times a year.

Of course, compounds in Njoben, as in all other communities, can have their own individual cooperative arrangements to serve as bilateral support systems. Labor, tools, food, and many other resources are exchanged between family groups in the same village. While the large survey undertaken for this study captures the main transactions (for instance, labor and food), an in-depth study further explores these linkages (Webb 1989). Such links may also include the exchange of youths for marriage and often date back several generations. It is unusual for any given compound to enjoy close links with fewer than three other compounds in their community.

The Compound Economy

The Gambian compound is the structure that serves as the arena for family interactions. In physical terms, the compound constitutes a collection of dwellings, kitchens, and storage huts clustered around a central courtyard and fenced off from the pathways outside. The average number of people living in the compounds studied was 13.7 but

[10] For more details of the Strange Farmer system, see Swindell (1985) and Robertson (1987).

the range was from 2 to 86. Compound size was related to ethnicity (Serahuli had the largest mean, 19.4 persons, and Fula the smallest, 11.4 persons). Size was also related to age. New compounds tended to be smaller; those less than 1 year old averaged 8.3 persons, while those over 10 years old averaged 15.8.

The nucleus of the compound membership is a grouping of blood-related kin, but the total household may also include more distant relatives and even unrelated Strange Farmers among its inhabitants. Each household member holds a well-defined position in the compound microsociety that is ascribed according to hierarchies of age, sex, and marital status.[11] Ultimate responsibility for the maintenance of productive cooperation lies with the compound head. Yet the compound head is not omniscient. However powerful and domineering a single figure of authority may be, it is impractical for one person to make all the decisions that are necessary in the running of a large household of diverse individuals. Subdivisions of distinct spheres of responsibility and activity are apparent in many (especially larger) compounds.

The Compound Subunits

There are two main kinds of subdivision of the compound unit. On the one hand, compound membership may be subdivided into *dabada* and *sinkiro.* On the other hand, the compound farm is divided into a communal *maruo* section and private *kamangyango* sections.[12]

The *dabada* (a Mandinka word deriving from the noun *daba,* or hoe) is generally defined as a farm production unit. If all members pool labor to produce food on which the compound subsists, then the *dabada* is coincident with the compound. This is the case in 86 percent of the sample compounds. If, however, two or more groups of individuals living within the same compound decide to split their farming ventures, then that compound may contain as many as four *dabada*s (the sample contains 16 compounds with two *dabada*s and four compounds with four *dabada*s each). *Dabada* structures change frequently. Therefore, production data were gathered on an individual field-by-field basis from each person responsible for fields in each whole sample compound.

Cooking and consumption groups, called *sinkiro*s in Mandinka, provide the basis for the compound's organization of storage, processing, and consumption of food. In larger *sinkiro*s several women may be responsible for cooking; typically, each woman cooks on a rotational basis. The head cook of the *sinkiro,* usually the highest-status active female, supervises the cooking procedures, establishes the duty roster of the cooks, and organizes the provision of ingredients.

The cooked food is normally divided into a number of bowls that are presented to "eating groups." Many combinations of these eating groups are possible in a compound by age and gender. Sometimes people from different *sinkiro*s join in eating groups, but rarely people from different compounds.

Among the Mandinkas, the women of the same *sinkiro* traditionally also work together as a distinct production unit. A *sinkiro* is thus not just a cooking unit in these instances where the women produce traditional rice as both a communal and an individual crop independently from the male-headed *dabada*s.

In most of the sample households, the *dabada* and *sinkiro* units coincide with the compound (80 percent of the compounds have only one *dabada* and one *sinkiro*). Some

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[11] For a more detailed account of the decisionmaking structures of intracompound hierarchies, see Webb (1989).

[12] For complementary accounts of Gambian household organization, see Dey (1982) and Dunsmore et al. (1976).

of the larger compounds may be subdivided into several working and consumption groups. Ethnicity plays a role in this pattern. In the study area, this applies especially to Mandinka and Wolof compounds, where some of the traditional responsibilities of the compound head are transferred to the heads of the subunits.

In subdivided compounds, where the number of *sinkiro*s equals the number of *dabada*s, all persons of one *sinkiro* usually also belong to the same *dabada* and the other way around. But sometimes *dabada* and *sinkiro* may differ: people from different consumption groups may pool their labor in one working group and share the produce after harvest. Such situations apply to 15 of the sample compounds. In these cases, the *sinkiro* was identified as the most stable and important decisionmaking unit for production, storage, and consumption decisions, even when agricultural production was technically organized partly in a different working unit. The final decision about the appropriate unit of observation was taken only after careful evaluation of each of the more complex cases of nonidentical production and consumption units within compounds.

The compound farm is also divided into two distinct parts: the communal *maruo* farm and the private *kamangyango* farm (communal refers to compound or *dabada* level, not to village level).

The *maruo* farm comprises a set of fields that is designated to provide the bulk of the food that will be required by the household until the following harvest. This enterprise, fundamental to the maintenance and survival of the compound group, is under the control of the compound head, either directly or through a production manager.

The harvest of a *kamangyango* field, by contrast, is allocated for individual rather than communal disposal. Any person in the compound (including the compound head) has the right to a *kamangyango* field for which he or she will be solely (or sometimes jointly) responsible. The number of *kamangyango* fields is naturally limited to the stock of land available to the compound and to the extent to which the head is prepared to subdivide existing fields. Boys and girls frequently get their own *kamangyango* field before the age of 14.

The communal crops are produced by the combined labor of all compound members—all men and women have a customary obligation to provide labor to the communal fields. Labor for the private crops, on the other hand, is organized by the individual who is responsible for the field. Individuals can choose to provide as much or as little labor to this crop as they want. However, this becomes one of the focal points of competition between personal interest and cooperation with the rest of the compound group. For those men and women with access to private fields, time spent on the communal farm or on other people's farms is time spent away from private crop production. And time spent on the private farm is time away from communal food production and time away from helping others.

This problem of balance between cooperation (adding to total availabilities) and conflict (dividing total availabilities among the members of the household) constitutes one of the so-called "bargaining problems" discussed by Sen (1985). The most common way that compound heads attempt to resolve the problem is to assign two or three days in the week as *maruo* workdays, on which all able-bodied compound members are expected to provide labor to the communal fields under the direction of the head, and the rest of the week as *kamangyango* workdays, during which individuals may allocate their own labor as they please. This allocation of up to three or four days a week to private farming results in a considerable amount of intrahousehold labor sharing at the individual level. Rather than pursue an individualistic concentration of labor inputs on their own plots, most farmers appear to favor a high level of cooperation among household members.[13]

Intrahousehold cooperation in the spheres of labor exchange and resource control was found to be an important factor in the successful adoption of the technology package offered by the Jahally-Pacharr rice project.

[13] This aspect is covered in von Braun and Webb (1989).

4

PRODUCTION EFFECTS OF COMMERCIALIZATION AND TECHNOLOGICAL CHANGE IN RICE

The country's first step toward expanding and improving rice production was taken in 1948 by the British Colonial Development Corporation. This initiative was driven by a desire to reduce costly food imports, which had become a necessity to offset frequent shortfalls in food production in various parts of the country caused by drought and insect damage. The swamps around Pacharr in the present study area were selected as the site for a planned 9,200-hectare irrigation scheme. Irrigation was achieved through the canalization of leveled fields, fed by the tidal flow of the river. The scheme was run on a plantation basis, with heavy work carried out by tractor; local labor was required only as daily paid hands for weeding. The first 60 hectares were planted in 1950, but only 6 hectares survived flooding that year because of insufficient drainage. Also, the heavy machinery was difficult to operate in the slippery conditions. Therefore, it was decided to involve local farmers on a sharecropping basis, but the scheme was not attractive enough to encourage the participation of many farmers. By 1958, fewer than 200 women had joined, cultivating a mere 120 hectares, and the scheme was abandoned in that year.

With support from Taiwan, the development of rice irrigation was resumed in 1966 around the area of Georgetown (30 kilometers upstream from the present survey area). This scheme was designed to assist farmers in establishing their own small perimeters for pump-irrigated double cropping. Inputs, such as fertilizer, seed, and fuel, were provided free for the first year, but farmers were expected to meet all costs themselves in subsequent years. The attraction of free inputs resulted in the development of 1,200 hectares by 1974. Since no support was given to farmers after the first crop, yields and productivity levels declined rapidly. Flooding continued to be a problem because of deficiencies in technical design. Unlined canals leaked and the lifespan of pumps and tractors was short because they were ill-adapted to local conditions.

The Taiwanese mission finally withdrew in 1974 to be replaced by personnel from mainland China. The latter committed themselves to furthering the work that had previously been carried out, using the same methods. However, by 1980, only 500-800 more hectares had been developed, and this scheme was suffering the same problems as its predecessors: mechanical failures, flooding, and declining yields.

Between 1972 and 1977, the World Bank also sponsored a scheme to consolidate the existing Taiwanese irrigation perimeters and to develop a further 1,200 hectares. The main departures of this scheme from the Taiwanese model were the continuous provision of inputs on credit and the establishment of a strict timetable for cultivation activity that farmers were expected to adhere to or be expelled from the scheme. When it was completed in 1977, less than two-thirds of the target area was developed, and countless farmers were falling behind on their loan repayments. By 1982, only 30 percent of the perimeters undertook dry-season irrigation and less than 10 percent attempted a wet-season crop. Nevertheless, some of the World Bank and Taiwanese perimeters continue to survive and to produce mainly wet-season crops. It is these perimeters that are referred to in later text and tables as the "old schemes."

Despite these many setbacks, The Gambia's planners have remained committed to the idea of large-scale irrigation. The latest attempt is the Jahally-Pacharr Smallholder

Rice Project, which is also seen as a pilot scheme to assess potentials for large-scale irrigation that could technically be developed following construction of a barrage that would prevent saltwater intrusion and permit regulation of river water flow in the dry season. Under the leadership of the International Fund for Agricultural Development (IFAD), the project is funded mainly by foreign donors and managed jointly by the Gambian Ministry of Agriculture and outside consultants.

Cost of Rice Production under Various Technologies

It is widely recognized that costs of irrigation schemes in Sub-Saharan Africa are high by Asian and Latin American standards. West African cost figures rank high even within the unfavorable African experience. However, comprehensive comparisons based on analogous calculations are lacking. Rough estimates suggest that new schemes in Africa cost 64 percent more than in the Far East and 55 percent more than in Latin America (FAO 1986, 39-49). This appears to be due to higher input (transportation), staff, and management costs. As the Food and Agriculture Organization of the United Nations (FAO) has underlined, "When all items of a project are added together, they tend to confirm the general statement that irrigation in Africa 'now costs US$15,000-20,000 per hectare,' provided that the definition of 'irrigation' includes full water control with pump supply on a site requiring a complete range of technical and production support services as well as social infrastructure" (FAO 1986, 42).

The Jahally-Pacharr project is no exception to that general statement. Conservative estimates suggest an investment cost of US$9,322 and total establishment costs of US$14,481 per hectare of irrigated land (all types) (Table 3). Investment costs cover

Table 3—Planned investments and running costs during establishment of the Jahally-Pacharr project, 1983-87

Investments/Costs	Share of Total Cost[a]	Cost per Hectare of Irrigated Land at Full Development, 1987[b]
	(percent)	(US$)[c]
Investments		
Civil works		
Land development	40.6	
Other	11.2	
Equipment, machinery, vehicles	12.6	
Subtotal	64.4	9,322
Running costs for project establishment		
Fuel	6.5	
Spare parts, maintenance	6.5	
Personnel (including expatriate staff)	22.6	
Subtotal	35.6	5,159
Total	100.0	14,481

Sources: Computed and estimated from Jahally-Pacharr project reports.
[a] Expenses for monitoring and evaluation and for social services are excluded.
[b] The land is expressed on a "pump-irrigated land equivalent" basis. The land area at full development of the project used for this calculation consists of 560 hectares of pump-irrigated land, 500 hectares of tidal-irrigated land, and 450 hectares of rainfed land. The respective areas are weighted on a yield basis. This results in 991 hectares of "irrigated-land equivalent."
[c] U.S. dollars are converted from special drawing rights (SDR) (1 SDR = US$1.216).

about 64 percent of establishment costs and most of this is for land leveling. While the experience of yields in irrigation projects is not very encouraging in many West African situations, this project stands out with impressive yields of about 5-6 metric tons[14] of paddy per hectare twice a year (from the pump-irrigated and drained and fully water-controlled plots). Project operating costs recently stood at US$317 per ton (excluding farmers' inputs and labor). As production costs for rice differ substantially by type of production technology, economic cost estimates are presented by technology later after a brief description of the project.

The Jahally-Pacharr project was initiated in 1983. By 1986 it covered 560 hectares of centrally pump-irrigated land, 188 hectares of tidal-irrigated land, and 432 hectares of improved rainfed land. Two crops a year are harvested from the centrally pump-irrigated plots. Only one annual crop is usually harvested from the partly water-controlled land, which is partly tidal-irrigated and partly improved rainfed rice or a mix of the two.

Land in the project is distributed to about 7,500 farmers who cultivate an average of 0.43 hectare of fully water-controlled equivalent land per compound.[15] Farmers repay loans for land preparation, water, seed, and fertilizer charges by selling back part of their produce to the project immediately after harvest.[16] Loan repayments showed an unusually good record in the first few years of project operation, with 92-99 percent recovery, but have declined in recent years, when yields have been lower. The charges to the farmer on a per hectare basis represent 25 percent of the average output per hectare in 1986 and have been adjusted to increased input cost over the years.

Producer prices for project paddy paid by the local cooperative were D945 in 1986.[17] This is equivalent to US$263 per ton of white rice at a parallel exchange rate (in 1986, US$1 = D6) and a milling rate of 0.6. The white rice price for consumers in Banjul in 1986 was about D1,793 (US$299). Rice was taxed both through import restrictions and through a direct tax, which amounted to a 44 percent tax rate for urban consumers in 1986. Between 1977 and 1985, this ranged between a tax of 25 percent and a subsidy of 10 percent, with the average being a 15 percent tax.[18] Thus, during the 1980s, The Gambia was not among those countries that pursued a "cheap food policy" by world market standards.

In the following cost calculations, a distinction is made between fully water-controlled (pump-irrigated) rice in the project that yields two crops a year, partly water-controlled rice in the project that yields one crop a year (tidal-irrigated and rainfed), and swamp rice outside the project. Cost calculations per hectare and per ton of milled rice are broken down by major cost categories and by domestic and foreign exchange costs in Table 4. The analysis is then further developed to include domestic resource cost (DRC) calculations in Table 5.[19]

The DRC approach is used to estimate comparative advantage in rice production under alternative technologies vis-à-vis the import option. The DRC is thus the cost in

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[14] All tons referred to in this report are metric tons.

[15] For comparative purposes, land in the project is expressed in "fully water-controlled equivalent land" based on the different yield levels.

[16] Cash payments are also possible, but this option has only recently been chosen to a more significant extent by farmers.

[17] D is the currency abbreviation for the Gambian dalasi. In September 1985, US$1.00 equaled D3.50 at the official exchange rate and D5.06 at the parallel market rate; in June 1987, US$1.00 equaled D7.50, with little difference between the official and the parallel rates.

[18] For the detailed price and tax calculations based on the parallel exchange rate and taking account of handling costs, see Johm (1988).

[19] On the concept of DRC, see, for instance, Bruno (1972) and Gittinger (1982).

Table 4—Production costs of rice in various technologies, 1985

Position	Share of Foreign Cost	Production Costs of Jahally-Pacharr Project Rice: Fully Water-Controlled Rice (Sum of Double Crop) Total	Domestic	Foreign[a]	Partly Water-Controlled Rice (Single Crop) Total	Domestic	Foreign	Production Costs of Swamp Rice (Single Crop) Total	Domestic	Foreign
	(percent)	(dalasi/hectare)		(US$/ hectare)	(dalasi/hectare)		(US$/ hectare)	(dalasi/hectare)		(US$/ hectare)
Investment costs[b]	75	5,370	1,342	796	1,497	373	222	. . .	. . .	. . .
Operation cost (annual)	90	1,785	179	317	432	43	77	. . .	. . .	. . .
Other variable production cost[c]	46;25	1,860	1,004	169	527	285	48	160	120	8
Opportunity cost of unpaid labor[d]	15	1,427	1,213	43	756	643	22	718	610	21
Milling and handling[e]	50	937	468	93	286	143	28	121	61	12
Total cost per hectare		11,379	4,206	1,418	3,498	1,487	397	999	791	41
Share of equivalent foreign exchange cost in total cost (percent)		(63.1)			(57.5)			(20.8)		
Share of investment cost in total cost (percent)		(47.1)			(42.8)			(0.0)		
Total costs per metric ton (dalasi)[f]		1,635	604	204	2,082	885	236	1,297	1,027	53
Total costs per metric ton (US$)		323			411			256		
Total costs per metric ton, excluding investment cost (US$)		171			235			256		

Source: Computed and estimated from Jahally-Pacharr project reports.

[a] Computed at shadow exchange rate when conversion required (1985: US$1.00 = 5.06 dalasi).

[b] Total investment costs annualized based on 10 percent interest and 30-year repayment period. Fully water-controlled land required investment cost of US$10,000 per hectare; partly water-controlled, US$2,792 per hectare.

[c] Economic cost for situation with the average sample survey yields (fertilizer, seeds, and so forth); 46 percent refers to "fully water-controlled."

[d] Using prevailing male and female wage rates in respective seasons (wet season, D3.50; dry season, D1.50). Fifteen percent of the opportunity cost of unpaid labor is specified under foreign cost. This 15 percent is estimated to represent the average share of unpaid labor's opportunity costs accounted for by foreign exchange earning activities (seasonal groundnut production in neighboring Senegal and other migration-remittance relationships).

[e] Based on 10 percent of value of output.

[f] Based on mean rice yield (milled rice, metric tons per hectare per year) from sample survey: fully water-controlled rice, 6.96 tons; partly water-controlled rice, 1.68 tons; and swamp rice, 0.77 tons.

Table 5—Domestic resource cost calculations for various rice technologies, 1985/86

Position	Jahally-Pacharr Project Rice		Swamp Rice
	Fully Water-Controlled	Partly Water-Controlled	
	(cost/metric ton of milled rice)		
Domestic production cost (dalasi)[a]	604	885	1,027
Rural marketing (dalasi)	71	71	71
Total domestic production cost (dalasi)	675	956	1,098
Foreign production cost (US$)[a]	204	236	53
Domestic cost of importing rice into rural market (dalasi)	125	125	125
Foreign cost of importing rice into rural market (US$)[b]			
100 percent broken (Thai)	195	195	195
5 percent broken (Thai)	288	288	288
Domestic resource cost (DRC)[c]			
100 percent	negative	negative	6.85
5 percent broken	6.55	15.98	4.14
Resource cost ratio			
100 percent broken	negative	negative	1.35
5 percent broken	1.29	3.16	0.82
Critical c.i.f. import price of rice at which DRC would equal shadow exchange rate (US$1.00 = D5.06)	313	400	245

Source: Calculated from Jahally-Pacharr project records and the 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Notes: The calculations are based on the finding that the rural area of The Gambia is a net importer of rice. This is the case even if appropriate adjustments for border trade are made and is also confirmed by household-level supply and disappearance balances based on the International Food Policy Research Institute/Planning, Programming, and Monitoring Unit survey.

[a] For details, see Table 4.

[b] C.i.f. price Banjul (US$187/metric ton of 100 percent broken Thai rice and US$280/ton of 5 percent broken) plus foreign marketing cost into rural markets of US$8/ton.

[c] The domestic resource cost (DRC) is computed as follows on a per-ton-of-rice basis: DRC = (Total domestic production cost − domestic cost of importing rice into rural market) / (Foreign cost of importing rice into rural market − foreign production cost). For example, with the figures for fully water-controlled rice and the 5 percent broken-rice quality: DRC = 6.55 = (675 − 125) / (288 − 204).

domestic currency required to earn one unit of foreign exchange through a project. In economic analysis, a project is deemed successful if the DRC is less than the shadow exchange rate (Gittinger 1982, 398-400, 468). In the case under consideration, the DRC is the ratio of domestic cost of production and the difference between the border price of rice and the foreign exchange content of production and marketing costs:[20]

$$\text{DRC} = \frac{\text{Domestic cost of production in shadow prices per ton}}{(\text{c.i.f. import price per ton} - \text{foreign costs per ton})} . \quad (9)$$

Comparative advantage may be measured by the resource cost ratio (RCR) of DRC and the shadow exchange rate (SER) of the currency:

[20] As rural Gambia is a net importer of rice, the cost calculations are for a rural market point in the study region in central Gambia.

$$RCR = DRC/SER, \quad (10)$$

and if

$$RCR > 0 \text{ and } < 1, \text{ advantage; } 1, \text{ neutral; and } > 1, \text{ disadvantage.}$$

The calculations are made with 1985 prices, assuming sustained yield levels.

The cost of rice production per unit (ton) is higher in the two more advanced irrigation technologies than in swamp rice but decreases for the advanced technologies if investment cost is excluded. The share of foreign cost in total cost increases from 21 to 63 percent when swamp rice is compared with fully water-controlled rice.

The share of investment cost in total cost of the new technologies is 47 percent for fully water-controlled rice and 43 percent for partly water-controlled rice. The high cost of production per unit and the fact that the DRC exceeds the shadow exchange rate result from the high investment costs, which are mainly (75 percent) met from foreign capital.

While almost all of The Gambia's rice imports are 100 percent broken rice (which was available for an average of US$187 per ton in 1985), the critical import price at which domestic production at current cost structures and exchange rate would be viable is US$313 per ton in fully water-controlled rice and US$400 per ton in partly water-controlled rice. Swamp rice production is closer to competitiveness with a critical import price of US$245 per ton. If the import price of rice were at US$280 (which was also the 5 percent broken rice price in 1985), the fully water-controlled rice would show a DRC of D6.55—that is, to earn/save US$1.00, D6.55 is being expended in this technology, which is slightly above the shadow exchange rate of D5.06/US$1.00 in 1985.

These cost calculations give broad insights into the trade-offs between technologies. Clearly, cost of production has to come down substantially if the partly water-controlled rice technology is to be competitive. Yield potentials also need to be more fully exploited.

Because of a water shortage in the dry season, there is only a limited possibility for further expansion of fully water-controlled rice in The Gambia. Consequently, although almost viable under assumed long-term trends of international rice prices and under optimal project management conditions, this technology cannot hold the key to expanded rice production in The Gambia in the future. The future may be somewhere between the tested partly water-controlled technology (tidal and improved rainfed irrigation) and traditional swamp rice. However, it appears that partly water-controlled rice is not viable as analyzed here, because of large land-leveling and related investment costs. Smaller perimeters that require a lower per hectare leveling cost and still achieve comparable yields appear more competitive. In this context, it should be stressed that the partly water-controlled rice in the project shows a particularly broad spectrum of yield achievements (discussed later in this chapter). The project's function of identifying successful technologies within this setting has therefore been an important one in order to avoid misallocation of resources in future project designs.

The remaining part of this chapter describes and analyzes production relationships at the microlevel and how they are influenced by the new rice project. The analysis comprises, first, an analysis of the adoption of new technology, which in this case means gaining access to land in the project. Second, a quantitative account is given of how the division of land and labor between sexes, and between communal and individual farming, is changed by the new technology. Third, the effects on the output and labor productivity of various groups of farmers and on the crops that they produce are evaluated.

Access to the New Technology

Responsibility for crop production is divided between men and women. Men organize the bulk of upland cereals production, being responsible for more than 90 percent of those fields; women, on the other hand, organize swamp rice production (Gamble 1949, Weil 1973)—more than 90 percent of swamp rice fields are under female control. Both men and women are in charge of organizing traditional cash crop production. Women control close to 40 percent of all groundnut and cotton fields (Table 6), producing 28 and 29 percent of output, respectively.

Access to the new production technology—pump and tidal irrigation, coupled with fertilizer and improved seed—is tied to participation in the project. As project production is closely supervised, the "adoption" of new technology is largely synonymous with getting access to new rice land in the project through a more or less rationed distribution of land to villages, then intravillage to compounds, and finally within compounds to individuals or groups of compound members.

This distribution of the new rice land to farmers in the project poses problems of equity and efficiency. It is an issue of differentiation between villages, between compounds of the same village, and between male and female farmers of various socioeconomic characteristics in the same compound. In the Jahally-Pacharr project an equity-oriented approach to land distribution was attempted, whereby 0.5-hectare plots of land were given out to be shared, usually by compounds of the same village. As many as five compounds or different *sinkiro* groups may share the same 0.5-hectare

Table 6—Control over fields, by sex and male status in the compound, wet season 1985

Crop	Number of Fields in Sample	Fields Under Men's Responsibility: Total	Fields Under Men's Responsibility: Under Compound Heads	Fields Under Women's Responsibility
		(percent of all fields)		
Fully water-controlled rice in project[a]	174	90	69	10
Partly water-controlled rice in project[b]	103	23	22	77
Pump-irrigated rice in old schemes[c]	28	32	21	68
Swamp rice	302	9	2	91
Total	607	36	26	64
Early millet	302	91	53	7
Late millet	17	94	59	6
Sorghum	65	98	72	2
Maize	214	98	70	2
Total	598	95	62	5
Groundnuts	636	61	22	39
Cotton	83	63	22	37
Total	719	61	22	39
All crops	1,924	63	35	37
All crops, excluding rice projects	1,619	64	33	36

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

[a] These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

[b] These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

[c] These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.

plot and subdivide it. Land was distributed across a wide range of villages, some of which were inhabited by traditional rice farmers located close to the project, and others, farther away from the site, whose farmers had not been involved in rice farming before.

Land distribution criteria laid down at the outset stressed that priority access to project land would be accorded to traditional rice-cultivating villages (lowland villages that were much involved in swamp rice production before the project) and especially to women (Altarelli-Herzog 1983, 1984). Land allocation committees were set up to distribute quotas of plots to villages wishing to participate. At the village level, distribution committees were to organize the final distribution to compounds and individuals. In the event, different procedures were adopted by the project and consequently different patterns of distribution emerged. The final distribution at village level was handled very differently from village to village, depending on committee organization, the position of women in respective ethnic groups, and so forth. Thus the outcome of the distribution process poses important research questions that are more fundamental than simply whether administrative procedures were actually adhered to or not.

On average, 0.43 hectare was allocated per household unit (compound).[21] Equality of distribution varies considerably between villages (Appendix, Table 57) and within villages.

A more refined approach is used to assess the main determinants that shaped the final outcome of the land distribution. First, the characteristics of compounds that succeeded in obtaining more versus less of the project rice land are analyzed. Second, the factors that determined the probability of individual women gaining access to project land, and thus to the new production technology, are analyzed (see models shown in equations [1] and [2] in Chapter 2).

The first approach uses a regression model in which the amount of land per compound is the dependent variable. It was hypothesized that the size of a compound, its location in an upland or lowland village, and long-term residency and ethnicity affected the distributional outcome. Also, a test was conducted if compounds that had more land and farm capital endowments before the project had more access than others. Results of the multivariate analysis on compound-level distribution are presented in Table 7. The results suggest that the pattern of access does not fit a simple rich/poor or small farm/large farm distribution. All else remaining the same,

- Upland village compounds obtained 0.30 hectare less than those in lowland villages (variable 3), holding compound size constant (variables 1 and 2).
- Larger compounds (with larger work forces) obtained more land but at a decreasing rate (variables 1 and 2). Thus smaller units fared better on a per capita basis.[22]
- Mandinka compounds, traditionally more involved in rice production (by women), obtained significantly more access than all other ethnic groups (Wolof and Fula access is not significantly different from that of Serahuli) (variables 8, 9, and 10).
- Compounds that settled in the village longer than 10 years ago received on average 0.09 hectare more than their younger counterparts (variable 4). Higher status, which is usually related to compound age, affected project access significantly.
- Farm size and capital stock before the project did not significantly affect project access. There is thus no indication that the better-endowed compounds got significantly more access to the new technology (variables 5, 6, and 7).

[21] This area is expressed in terms of "fully water-controlled land equivalents," meaning that all rainfed and tidal-irrigated fields are converted on a yield-per-hectare basis to fully water-controlled land.

[22] For aggregate comparisons, persons are aggregated to adult-equivalent units on the basis of FAO-recommended calorie requirements: men = 1.00, women = 0.85, male 10-14 = 0.95, female 10-14 = 0.83, children 5-9 = 0.81, children 0-4 = 0.52.

Table 7—Determinants of access to land in the rice project, by compound (multivariate analysis)

Explanatory Variable	Parameter	t-Value
(1) Size of compound in adult-equivalent persons	0.0314	5.72
(2) Size of compound in adult-equivalent persons squared	−1.6024E−4	−1.73
(3) Upland villages (= 1, else = 0)	−0.2963	−4.32
(4) Long-term resident (compound older than 10 years)	0.0904	2.21
(5) Before-project farm size per adult-equivalent person	−0.0291	−0.17
(6) Before-project farm size per adult-equivalent person squared	0.0514	0.50
(7) Before-project farm capital per adult-equivalent person	6.4942E−4	0.64
(8) Mandinka	0.2661	2.86
(9) Wolof	−0.0658	−0.56
(10) Fula	0.0543	0.53
Constant	0.0144	
$\hat{R}^2$	0.718	
F-value	38.77	
Degrees of freedom	138	

Note: Dependent variable—amount of rice land in the project per compound in hectares (in fully water-controlled land equivalent).

The project's land-distribution policy was specifically aimed at ensuring women's access to the project rice land. Women were given land titles (long-term leases) in a formal registration process. To what extent this process translated into women's de facto control over land, and the right to cultivate it as their own *kamangyango* (personal) fields, was assessed separately. Results are taken from a random sample of women who reported having worked in the project fields in 1985/86. The results show that 52 percent of the women reported that they are *registered* as being responsible for a piece of project land. However, only half of those women actually control a field or are able to share one with other women. On the other hand, 29 percent of *unregistered* women have access to fields, mainly by sharing. Thus a total of 40 percent of the women in the sample ended up with a piece of land under their control. Nearly all of these fields are of the lower-yielding tidal-irrigated or rainfed type; only 10 percent of fully water-controlled fields are under female control, compared with 77 percent of the tidal/rainfed fields (Table 6). Most of the surveyed women (87 percent)—whether registered or not—work in the communal project fields.

The question of what determined women's access, or nonaccess, to the new rice fields is addressed next. A probit model is used to assess the factors that enhanced or reduced the probability of women's access to project rice fields. The dependent variable in the model is 1 or 0 (1 if a female farmer in the sample has her own rice field in the project). The qualitative response model is estimated, using Newton's method—that is, the variance matrix for the coefficients is estimated with the second derivatives of the log-likelihood.[23] There are 463 women included in this analysis. The model hypothesizes that women's access to new technology is determined by the socioeconomic and lineage characteristics of their compound and by their own individual status within the compound. The results of this analysis (see Table 8) are as follows:

- Women of higher status, that is, older women and *sinkiro* heads (who are usually first wives of compound heads), had a significantly higher probability of obtaining a field (variables 1, 2, and 3, Table 8).

[23] The program LIMDEP was used for estimation; see Greene (1986, 19.3-19.10) and Maddala (1983).

Table 8—Determinants of access of individual women to fields in the project (probit estimate)

Explanatory Variable	Estimated Parameter	t-Value	Change in Probability of Having Access to Field[a]
(1) Age of women[b]	−0.9847E−1	−8.39	−0.039
(2) Age of women squared	0.1232E−2	6.81	+ 0.005
(3) Woman is *sinkiro* head	0.8733	4.82	+ 0.350
(4) Woman is married to compound head	0.1471	0.78	. . .
(5) Woman was traditional rice grower[c]	0.4827	2.64	−0.200
(6) Number of women in compound[d]	−0.3610E−2	−2.52	−0.001
(7) Compound has more than one *sinkiro*	−0.1703	−0.95	. . .
(8) Size of land in project for whole compound[e]	0.7353	3.99	+ 0.290
Number of observations	463	. . .	. . .
Chi-squared	40.02	. . .	. . .

Note: Dependent variable—if a woman had her own field in the project or shared one with other women (= 1, else = 0).

[a] The probability is approximated from the estimated parameter by multiplying with the factor of 0.4 following an approximation approach described in Takeshi Amemiya, "Qualitative Response Models: A Survey," *Journal of Economic Literature* 19 (December 1981): 1483-1536.

[b] Age in years.

[c] Dummy variable = 1, if a woman had her own rice field in the area before the project *and* a personal rice store.

[d] Number of women of working age in the compound.

[e] Amount of project rice land in hectares expressed in irrigated land equivalent (for the whole compound).

- Traditional rice growers, defined as having had both a field *and* a personal rice store before the project, also had a significantly increased probability of obtaining a field (by 22 percent, variable 5); thus, traditional rice-growing women were protected to a certain extent by the distribution.
- Land allocation was carried out to the relative disadvantage of women in large compounds inhabited by many women (variable 6).
- The greater the amount of project land allocated to a compound, the higher is the probability of a woman in that compound gaining access to some of that land (variable 8).

To sum up this section, access to new rice land was widely distributed across the communities in the project region. At compound level, no apparent maldistribution by preproject resource endowments occurred. Ethnicity played a role in gaining access, partly as a result of different specializations of ethnic groups in economic activities and within agriculture. Contrary to the intent of the project, women were not the primary beneficiaries of the fully water-controlled land, but they did gain access to the partly water-controlled land. Among women alone, status characteristics were important in determining access to the improved rice land.

Technology Levels, Yields, and Control Over Crops

Much of the rice land in the Jahally-Pacharr project is used for growing a communal (household) crop. This is true for nearly all of the fully water-controlled land and for a substantial share of the tidal and rainfed plots (Table 9). The traditional upland cereals are also largely grown as communal *(maruo)* crops, while most of the cash crops (groundnuts and cotton) and swamp rice are grown as private *(kamangyango)* crops. Each upland communal field is under the responsibility of a man (usually the compound head), while the communal rice crop is customarily controlled by a woman.

Table 9—Use of communal and private fields in sample compounds, by crop and technology, wet season 1985

Crop	Overall Share of Land Use	Communal (Maruo)	Private (Kamangyango) Total	Men	Women
	(percent)	(percent of hectares of crop)			
Fully water-controlled rice in project[a]	5.8	99.0	1.0	1.0	...
Partly water-controlled rice in project[b]	4.1	87.0	13.0	3.0	10.0
Pump-irrigated rice in old schemes[c]	0.5	67.0	33.0	...	33.0
Swamp rice	10.7	17.0	83.0	6.0	77.0
Early millet	23.1	82.0	18.0	14.0	4.0
Late millet	1.1	81.0	19.0	14.0	5.0
Sorghum	4.2	88.0	12.0	12.0	...
Maize	9.1	92.0	8.0	8.0	...
Groundnuts	37.0	18.0	82.0	59.0	23.0
Cotton	4.5	15.0	85.0	59.0	26.0
All crops	100.0[d]	51.0	49.0	30.0	19.0

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.
[a] These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.
[b] These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.
[c] These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.
[d] Parts do not add to total because of rounding.

Women's control over rice fields declines according to yield (technology) levels in the various types of rice production (Table 10). This changing pattern of female responsibility for rice is, however, not simply a switch from a "women's crop" to a "men's crop," but a switch from a mixed communal food/private cash crop, grown mainly by women, to an almost purely communal crop under the responsibility of the (male) compound head.

A close look at the few cases (n = 17) of women who actually got access to fully water-controlled rice reveals that these are special cases. One woman is the wife of a

Table 10—Wet season yield levels and female control of rice fields, by technology, 1984 and 1985

Technology	Average Yield 1984	Average Yield 1985	Fields Under Control of Women 1984	Fields Under Control of Women 1985
	(metric tons/hectare)		(percent)	
Fully water-controlled rice in project[a]	6.6	5.2	14	10
Pump-irrigated rice in old schemes[b]	2.9	2.4	54	68
Partly water-controlled rice in project[c]	2.2	2.8	70	77
Swamp rice	1.3	1.3	95	91

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.
[a] These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.
[b] These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.
[c] These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

compound head who is a blacksmith, another's husband is a dry fish trader, a third is the wife of a shopkeeper. In some cases the compound head is rather old or unable to work or has recently passed away and the new compound head is a young boy, and in others the compound head is absent for an extended time. In all of these cases, the fully water-controlled land in the project is used by the senior women as communal land. This occurs even when the same women formerly cultivated their swamp rice as *kamangyango.* The project land thus serves to provide the staple food for consumption in these compounds. The rice crop from the fully water-controlled fields (which provide the highest yield per unit of land) is the one that is most completely transformed into a communal crop (99 percent, Table 9). The relative security of production from these fields and the drought conditions in the area in 1983-85 are important determinants of this.

Yet, while cross-sectional variation of the yields of this rice crop was low (0.27 in 1985, Table 11), yields in the rice perimeter with full water control (pump irrigation) do not appear stable over time. From 1984 to 1985, average yields in the wet season dropped from 6.6 to 5.2 tons, and a reduction occurred also in the 1986 dry season

Table 11—Yields of major crops and variances of yields in the sample, by season, 1984-86

Crop	Yield[a]			
	Wet Season		Dry Season	
	1984	1985	1985	1986
	(kilograms/hectare)			
Fully water-controlled rice in project[b]	6,552 (0.24)	5,171 (0.27)	6,488 (0.27)	5,072[c]
Partly water-controlled rice in project[d]	2,187 (0.73)	2,797 (0.54)	...	...
Pump-irrigated rice in old schemes[e]	2,862 (1.03)	2,362 (0.97)	2,471 (0.59)	...
Swamp rice	1,274 (0.77)	1,277 (0.77)	...	...
Early millet	855 (0.82)	1,103 (0.80)	...	...
Late millet	760 (1.16)	1,127 (1.14)	...	...
Sorghum	197 (1.17)	259 (0.92)	...	...
Maize	402 (1.56)	616 (1.16)	...	...
Groundnuts	1,244 (0.73)	1,214 (0.65)	...	...

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.
Note: Numbers in parentheses represent coefficients of variation.
[a] The yields are from fields harvested; yields per hectare of land sown are less in the case of upland cereals and groundnuts, especially in 1984, due to drought effects.
[b] These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.
[c] Based on a subsample of only 10 percent of households.
[d] These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.
[e] These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.

(1986 dry-season data are based on a subsample only). The reduction in yields in the wet season is apparently a consequence of increased competition for scarce labor in upland crops. This issue will be addressed below.

Effects of Project on Labor in Subsistence and Cash Crops

Given the average input of 349 person days per hectare per season, the pump-irrigated fields in the fully water-controlled part of the project require 61 percent more labor per hectare than does swamp rice (Table 12). This is the case even though many of the necessary land preparation activities are centrally provided to farmers by the project. Hired labor, usually paid in cash, makes up a substantial share (25 percent) of the total labor input to fully water-controlled fields and 11 percent of the labor input to partly water-controlled fields. Among other crops, 9 percent of the labor input for cotton production is met by hired labor, 6 percent for groundnuts, and 2-3 percent for upland cereals. The recent expansion of the market for hired labor in rice, which hardly existed before, is clearly associated with the new project.

A central question frequently asked is, "To what extent is the shift between men and women in responsibility for crops (fields) also reflected in a transfer of labor between crops?" Or, more specifically, "Do women now perform much of the work on the male-controlled communal rice fields, whereas before they were working for income or food under their own control in their individual rice fields?" In answer to the first question, the share of women's labor in total family labor for the four different rice technologies generally follows the pattern observed for responsibility over fields. Therefore, the answer to the second question is generally no. In swamp rice, where women are responsible for 91 percent of fields, they provided 77 percent of the family

Table 12—Hired and family labor input per hectare, by crop and technology, wet season 1985

Crop	Total Labor	Total Hired Labor	Total Family Labor[a]	Family Labor[a] Men	Women	Children
	(person days/ hectare)	(percent of total labor)		(percent of family labor)		
Fully water-controlled rice in project[b]	349	25	75	69	29	2
Partly water-controlled rice in project[c]	262	11	89	39	60	1
Pump-irrigated rice in old schemes[d]	377	7	93	24	68	8
Swamp rice	217	5	95	17	77	6
Early millet	95	3	97	83	10	7
Late millet	84	2	98	91	3	6
Sorghum	87	3	97	95	1	4
Maize	90	3	97	80	9	11
Groundnuts	141	6	94	69	26	5
Cotton	132	9	91	57	39	4
Total average	. . .	7	93	62	32	6

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

[a] Strange Farmers are included in family labor, since they are not paid in cash and reside within the compounds for an extended period.

[b] These fields are in the pump irrigated perimeter of the project. They produce two crops a year.

[c] These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

[d] These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.

labor in 1985. In the fully water-controlled fields of the project, of which women control 10 percent, they provided 29 percent of the family labor input (Table 12). The two other types of rice technologies range between these two extremes.

The close correlation between responsibility for crop production and labor input by sex for that crop also appears in the upland crops. Women do little work in the upland cereals when they are not responsible for them, and their input into groundnuts and cotton is about the same as the corresponding share of land under their responsibility. For instance, women provide 26 percent of all family labor in groundnuts, and their fields cover 27 percent of the total groundnut area in the sample.

In the wider picture of division of labor, women provide 32 percent of all family labor in this sample for the major field crops and men provide 62 percent (Table 12). Although general discussions frequently assume higher figures for women's labor in agriculture in Africa, this finding is in line with results from other detailed studies on women's labor input in West African agriculture.[24]

Earlier research on rice in this location, with less coverage of ethnic groups and agroecological settings, found much rigidity of sexual division of labor by crop (Dey 1982). The present study indicates that the men provide 17 percent of all family labor to swamp rice production, which is almost exclusively a women's crop. At the same time, women are responsible for 29 percent of all private groundnut and cotton production, and men also provide considerable amounts of labor on these private upland fields.

With regard to ethnic differences, there are indeed substantial differences within this sample. In the upland villages, the Fula and Wolof ethnic groups predominate, while Mandinka and Serahuli are the majority groups in the lowland villages. Upland villages, which are farther away from the new rice land, use more hired labor in their project fields (29 percent), and very little of the project work is done by women (8 percent). Women from these villages, who are not traditional rice farmers, work to a greater extent in upland cereals (15 percent) and in groundnuts (34 percent).

There exists a fair amount of labor-sharing between women and men. Twenty-four percent of the work in the fully water-controlled fields that are under male control is accounted for by hired labor; the remaining 76 percent is family labor, of which 26 percent is provided by women. The few women who are responsible for a rice field of this type use more hired labor (35 percent) and provide more of the total family labor to such fields themselves (51 percent). In Table 13 the division of labor is presented for all fields separately by communal and individual organization. In general, it is found that when a field is under communal organization and controlled by a man (usually the compound head), most of the family labor input comes from men. This is least pronounced in the case of partly water-controlled rice, which is generally more of a "women's crop." But apart from this case, men contribute 72-86 percent of family labor in the communal fields that are male-controlled. In general, this pattern holds true also for communal fields controlled by women. Here women provide most of the field labor, but with the exception of traditional rice, this pattern is not so pronounced as in the case of male-controlled communal fields.

A fair amount of labor-sharing occurs in individual fields controlled by women, especially in the cash crops—groundnuts and cotton. Women receive a substantial share of family labor input from men in their own mostly private *(kamangyango)* fields. In women's own groundnut fields, for instance, women provide 48 percent of the family labor, while 47 percent comes from men, who are usually their husbands.

[24] For a review and a more specific evaluation of this issue, see von Braun and Webb (1989).

Table 13—Division of labor between men and women in communal and individual farming, by crop, wet season 1985

Crop	Organization	Share of Family Labor[a]: Fields Controlled by Men: Number in Sample	Men	Women	Fields Controlled by Women: Number in Sample	Men	Women
			(percent)			(percent)	
Fully water-controlled rice in project[b]	Communal	155	72	26	18	44	51
	Individual	...	...	...	...	...	...
Partly water-controlled rice in project[c]	Communal	23	62	37	61	29	70
	Individual	...	...	...	16	40	59
Swamp rice	Communal	...	...	...	30	4	86
	Individual	24	58	38	245	14	80
Early millet	Communal	209	86	8	...	...	...
	Individual	67	86	5	22	56	40
Groundnuts	Communal	79	86	7	...	...	...
	Individual	308	82	13	241	47	48
Cotton	Communal	...	...	...	...	...	...
	Individual	43	73	22	27	27	71

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

[a] The child labor share is not listed, so respective figures do not add up to 100. Cases with less than 10 observations in the sample are not listed.

[b] These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

[c] These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

The next question to be addressed is, "What is the total agricultural workload of men and women farmers and how did it change under the new rice project?" The marked seasonality of rainfed agriculture does not permit continuous work in the fields. Of total available workdays—about 165 days over the entire wet season—men spend 70 percent and women 36 percent in field crop production (including related preparation and transportation activities). In the dry season, men spend 24 percent and women 13 percent of available time in irrigated rice work. Overall, men in lowland villages of the project area spend a lower share of their time in crop production than men in upland villages (62 percent versus 84 percent in the wet season), but the opposite is true for women (39 percent in the lowland versus 32 percent in the upland villages). Women's work in rice is a main factor in determining this difference. Yet, although labor allocation differs widely by crop between upland and lowland villages and between men and women, the total time spent in agriculture is similar—52 and 57 percent, respectively, of available time in the wet season. It should be stressed that during the wet season there are various labor peaks, especially at times of upland crop weeding and rice transplanting.

The new rice project provides additional employment, particularly in the dry season when there is underemployment, and it induces a substitution effect between work on other crops and work on the new rice fields during the wet season. This is demonstrated in Table 14, where households are grouped by the amount of new rice land available per adult-equivalent person. In the dry season, women and men in the lowest quartile spend 3 percent and 11 percent, respectively, of their time in agriculture, while in the highest quartile they spend 24 percent and 36 percent, respectively.

Table 14—Allocation of men's and women's labor to major crops, by amount of project land cropped per household, 1985

Amount of Land in Rice Project[a]	Time Spent on Crop as Share of Total Available Labor Time in Season				
	Dry Season	Wet Season			
	Rice	Rice	Millet and Maize	Groundnuts and Cotton	Total
			(percent)		
Men					
Lowest quartile	11	7	31	39	77
Second quartile	19	18	30	32	80
Third quartile	27	23	21	23	67
Highest quartile	36	29	16	13	58
Average (all men)	24	17	25	28	70
Women					
Lowest quartile	3	9	6	19	33
Second quartile	8	25	4	12	40
Third quartile	15	27	1	7	36
Highest quartile	24	33	. . .	4	38
Average (all women)	13	23	3	11	36

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.
Note: Parts may not add to totals because of rounding.
[a] The quartiles are formed on the basis of amount of land per capita in "irrigated land equivalent area" (area is weighted based on yields in the different technologies in the project area). Mean yields are used as constant weights, so are not influenced by variations in plot-specific land quality (drainage) and input levels.

With increased availability of project rice land, wet season work patterns by men and women show strikingly different tendencies. Men's total work in agriculture decreases from 77 percent to 58 percent of available time (from 127 to 96 days), while women's total work increases slightly (Table 14, last column). This may point to a "leisure" effect for men, or to increased nonfarm work, which is apparently not shared with women. This question is addressed later in a more refined analysis of the reallocation of labor between crops.

It appears that the expansion of men's labor in rice (Table 14, column 2), which results in higher absolute returns per day of work for this communal crop, is accompanied by a higher absolute reduction in labor inputs to the upland crops than in the case of women (Table 14, columns 3 and 4).

The substitution effects between new rice fields and upland crops and swamp rice in an environment of land surplus (in the upland and swamp areas) are mediated through the competition between crops for scarce labor. However, this competition is also reflected in the resultant land-use patterns. In order to assess this, it was possible to draw on longitudinal information obtained in careful recall surveys on a field-by-field basis with the survey farmers. The aggregate results show that total land area cultivated, including the new rice fields, expanded from 1983 to 1985 (the 1984 area increased by 6 percent over 1983 and in 1985 the area was 3 percent larger than in 1983). The area under all other crops dropped by 8 percent (Table 15). In general, this is due to the reduced upland crop production (−10 percent of area) rather than reduced traditional rice production, which declined only for an intermediate year but actually rose again in 1985. As one would expect, those compounds that received large pieces of land in the project most reduced the area of upland crop and swamp rice that they cultivated between 1983 and 1985 (by 27 percent). Conversely, compounds in the lowest quartile (of rice land per adult equivalent) actually expanded the land under all nonproject crops by 7 percent in the same period.

Table 15—Changes in land use by sample households under the new project, by amount of rice land cropped, 1983-85

Household Quartiles of Project Rice Land per Adult-Equivalent Person	Hectares in Whole Sample 1983	Area of Upland Crops and Traditional Rice, Index 1983 = 100: 1983	1984	1985
Lowest quartile	283	100	108	107
Second quartile	216	100	97	93
Third quartile	185	100	88	81
Highest quartile	110	100	74	73
Total	794	100	96	92

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Production Organization and Profitability of Different Technologies

Obviously, there is an opportunity cost for the labor pulled away from the upland crops and swamp rice into the new rice fields. If the difference between the opportunity cost of labor established by the net returns to wet-season upland work and actual net returns to the new fields is small, the net benefit to participants and society will be small (as long as the land-abundant situation prevails in the area). To address this critical issue, a gross margin calculation is performed on a field-by-field basis for the whole sample for all major crops. Gross margin refers to the output product multiplied by the sales price (if nothing was sold, the village-specific average market price for that commodity was used) minus all variable input costs, including seed, fertilizer, hired labor, and other inputs such as charges for water and tractor-powered land preparation in the rice project. The gross margins are then related to unpaid (family) labor and to field size. Mean values of the computations and their coefficients of variation are presented for all major crops in Table 16. It should be noted that these are private returns, not economic (social) returns. The rice production in the project includes a substantial subsidy element, as discussed in Chapter 3.

The average labor productivity in the fully water-controlled rice fields is by far the highest, at D14.70 per person-day. This rice technology requires about 15 times the variable cost per hectare compared with swamp rice and about three times the variable cost per ton of paddy. The need for financing these variable costs is clearly substantial. A credit facility operating in the project provides financing for fertilizer, seeds, and irrigation. But other costs for transport, hired labor when required, and threshing may be significant, too. On average, the other rice types were less remunerative in 1985 than the traditional upland crops (millet/sorghum and groundnuts). In the partly water-controlled fields, mainly operated by women, labor productivity was only half of that in the fully water-controlled fields, but still 30 percent higher than in swamp rice. It should be noted that returns to labor in upland crops were curtailed in 1985 by an unusual fertilizer shortage in The Gambia that affected the upland crops and traditional rice of the sample farmers but did not affect the rice in the project (von Braun and Puetz 1987). Returns to labor in the upland crops were, therefore, rather below the level of a "normal" year.

A compound head who was able to switch his work force from millet/sorghum production for the common food stock to rice in the fully water-controlled section of

Table 16—Farm-level profitability of rice technologies and major field crops, wet season 1985

Crop/Technology	Average Gross Margins[a] and Their Coefficients of Variation[b]: Per Person-Day of Family Labor	Per Hectare	Variable Costs per Hectare
		(dalasi)[b]	
Fully water-controlled rice in project[c]	14.7 (0.87)	2,938 (0.46)	1,766
Partly water-controlled rice in project[d]	7.4 (0.96)	1,371 (0.72)	925
Pump-irrigated rice in old schemes[e]	3.8 (1.48)	1,720 (1.20)	538
Swamp rice	5.7 (0.75)	1,041 (0.81)	122
Millet, sorghum	9.0 (0.89)	731 (0.97)	45
Maize	6.6 (1.30)	495 (1.29)	50
Groundnuts	8.7 (0.87)	943 (0.77)	266
Cotton	3.2 (1.38)	375 (1.47)	92

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

[a] Gross margin (net return) is calculated as the difference between value of (marketable) output minus variable costs (including hired labor).

[b] Coefficients of variation are in parentheses.

[c] These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

[d] These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

[e] These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.

the project gained D5.70 per workday per person of his work force (D14.70-D9.00). In other words, the communal work force needed to work 39 percent less to obtain a similar return (D5.70/D14.70).

Returns to labor in men's fields are higher than in women's fields. This holds true for the individual crops (groundnuts, cotton, and swamp rice) where both men and women have control, and also for the different technology levels in rice (Table 17). The returns to labor in women's fields (partly water-controlled) are 44 percent below men's (fully water-controlled): 39 percent below men's for swamp rice, 35 percent below for groundnuts, and 49 percent below for cotton. An explanation for these consistent differences requires careful consideration of the input and output side of women's field operations. Lower average labor productivity for women is suggested by women's multiple work load in home activities (with the related organizational problem of timeliness in field operations such as preparation and weeding), reduced ability to make decisions on labor allocations within the household and establish a reliable and enforceable labor-sharing arrangement, and reduced benefits from related scale economies. For instance, women's individual groundnut fields are 50 percent smaller than men's. Unproductive walking time to the fields is, therefore, twice as high per

Table 17—Gross margins per person-day in fields under male control and under female control, wet season 1985

Crop/Technology	Average Gross Margin per Person-Day: Men's Fields	Women's Fields
	(dalasi)	
Fully water-controlled rice in project[a]	13.9	b
Partly water-controlled rice in project[c]	b	7.8
Swamp rice	8.9	5.4
Millet, sorghum	9.1	8.0
Maize	6.7	b
Groundnuts	10.0	6.5
Cotton	3.9	2.0

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.
Note: Gross margin (net return) is calculated as the difference between value of (marketable) output minus variable costs (including hired labor).
[a] These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.
[b] Less than 25 observations and therefore not shown.
[c] These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

unit of output in women's fields at same yield levels. Women's swamp rice fields tend to be located far from the compound, which results in a high share of working time spent traveling to and from the field. Also, women own far fewer labor-saving implements than men (Table 18). This may be a critical factor in timely use of implements and in breaking labor bottlenecks at times of planting and weeding.

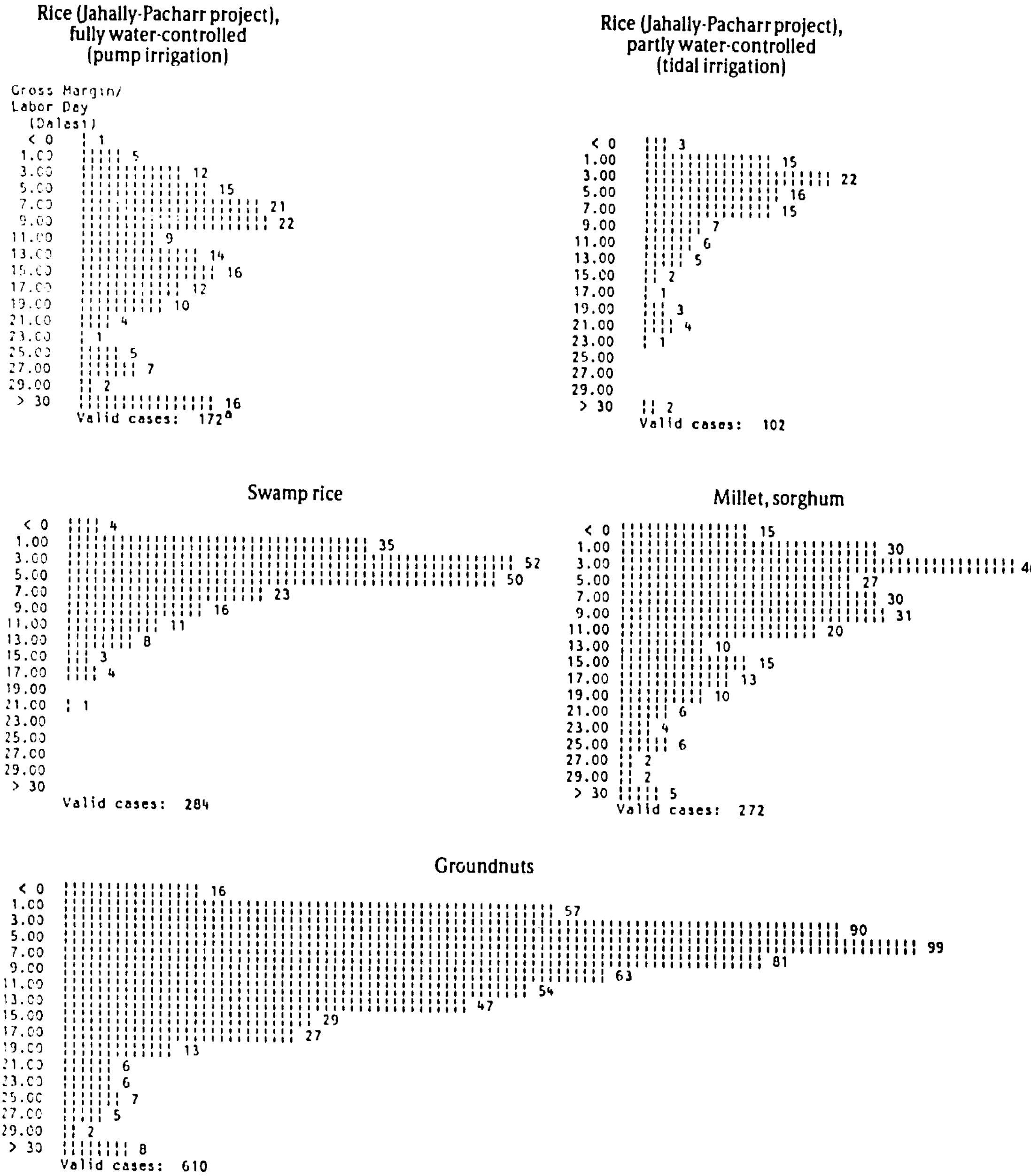
Although the average returns to labor in the fully water-controlled rice in the project substantially exceed the average returns to all other crops, it must be recognized that a substantial number of farmers manage to achieve similar productivity levels in upland crops (see Figure 5). The average return of about D15 per day for fully water-controlled rice is achieved, or even exceeded, by 23 percent of farmers with upland cereals and 17 percent of farmers with groundnuts. The majority of groundnut and millet farmers exceed the average returns per labor day achieved by farmers in the partly water-controlled rice fields of the project.

Table 18—Ownership of labor-saving implements by men and women farmers, wet season 1987

Implement	Men	Women
	(percent owning the tool)	
Plow	8.2	0.0
Seeder	26.9	0.6
Weeder	12.4	0.2
Multipurpose implement[a]	18.1	0.4

Source: 1987/88 follow-up survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.
[a] An animal-drawn implement convertible for plowing, weeding, and groundnut lifting.

Figure 5—Distributions of returns to labor, by crop, wet season 1985



Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

[a] Cases refer to number of farmers (male and female).

Labor Productivity in New Rice and Traditional Crops

The purpose of the following analysis is to assess the total and marginal opportunity costs of the new rice crops as established by the returns to labor that would otherwise have remained in upland crop and swamp rice production. An assessment is then made of the effects of labor reallocation on food production, manifest in the additional project rice output, which has supplanted a certain amount of production in the upland cereals, upland cash crops, and swamp rice because of competition with labor.

Production Functions

Production functions are estimated to evaluate marginal labor productivity in the various crops. The reallocation of labor induced by the labor demand from the new rice fields is analyzed with the help of labor input functions thereafter (see also conceptual framework in Chapter 2, equations [3] and [4]).

The production functions are specified for main field crops and take the institutional setting, such as communal versus individual field and field under male versus female control, into account and are quadratic in the main inputs to permit decreasing marginal returns.

A note of caution is in order here regarding the general problem of estimating technical input-output relationships on the basis of cross-sectional farm-survey data that are not structured for a strictly controlled experiment. Capturing the factors of variability in managerial skills and in agroecological microconditions poses a particular problem of latent unobserved variables. An attempt was made to take account of these by including variables depicting crop responsibility along gender lines, distance of field from village (the closer ones among upland villages tend to get more manure from grazing animals), and the somewhat better soil conditions in a particular zone among the upland villages along the border to Senegal. The main differences in agroecological conditions are taken into account by separately specifying the production function for the upland areas (soils of sandy detrital sediment of relatively low fertility) and for the lowland areas (hydromorphic soils).

While the main purpose of the production function estimates is to arrive at marginal labor productivity, the authors also want to assess the effects of crop-specific implement use and institutional setting (communal fields, share of fields under women's control) on output. The dependent variable is the total production of the respective crops from communal and individual farming per compound (or compound subunit in the case of some large Wolof and Mandinka compounds) in the wet season of 1985. Slightly modified for the various crops, the production functions have the following formula:

$$Q_{ji} = f[FSIZE_{ji}, LAB_{ji}, (LAB_{ji})^2, FER_{ji}, (FER_{ji})^2, TECH_{ji}, INST_{ji}, SOIL_{ji}], \qquad (11)$$

where

Q_{ji} = production of crop j on farm i,

$FSIZE_{ji}$ = size of field(s) in hectares,

LAB_{ji} = total labor input in person-days (paid and unpaid labor) per hectare,

FER_{ji} = fertilizer use per hectare,

$TECH_{ji}$ = set of dummy variables on implements used (see Table 19 for specifics),

$INST_{ji}$ = set of institutional variables (such as communal field, women's fields; see Table 19 for specifics), and

$SOIL_{ji}$ = soil dummy variable for better soils in border zone within upland area.

The estimation results are presented in Table 19. The results are largely consistent with expectations.

Table 19—Production functions of major field crops

Variable[a]	Upland Cereals—Millet, Sorghum, Maize		Groundnuts		Partly Water-Controlled Project Rice and Swamp Rice[b]	
	Parameter	t-Value	Parameter	t-Value	Parameter	t-Value
HAFERT	7.2962	1.54	7.5200	1.97	1.0208	0.29
HAFERTSQ	9.1866E−3	−0.29	−0.0272	−1.18	−1.29542E−0	−0.10
HALAB	10.2593	2.19	7.2779	2.04	8.9287	3.23
HALABSQ	−0.0189	−1.20	−0.0109	−1.28	−0.0127	−2.56
WRKWOMAE	−431.3700	−0.68	−1,113.5900	−1.89	1,210.2085	1.73
MARUOSH	198.4560	0.53	117.0740	0.59	−299.3296	−1.20
WOMENSH	827.9140	1.31	−462.1430	−1.39	304.7832	0.97
SIZEFLD	983.0190	14.78	1,193.1750	23.20	1,545.7655	19.55
DISTANCE	−5.2980	−0.69	1.0661	0.27	−3.1940	−0.68
SINEUSE	173.2760	0.93	−165.4460	2.69	. . .	. . .
PLWUSE	−173.9970	−0.95	−829.6420	−1.03	. . .	. . .
SOIL	1,021.1590	4.70	441.0320	2.18	. . .	. . .
JPSHARE	. . .	. . .	. . .	. . .	1,392.1316	4.39
Constant	−1,389.2570	−2.54	−723.0742	−1.93	−2,093.7082	−3.38
$\bar{R}^2$	0.671		0.821		0.796	
F-value	34.39		72.62		45.59	
Degrees of freedom	184		175		117	

Note: Dependent variables—output of crops per compound, or compound subunit in the case of large Wolof and Mandinka compounds.

[a] Definitions of variables in the production function:

HAFERT = fertilizer applied per hectare in kilograms of material;
HAFERTSQ = HAFERT squared;
HALAB = total labor input in person-days per hectare;
HALABSQ = HALAB squared;
WRKWOMAE = number of women in household of working age per adult equivalents;
MARUOSH = share of fields of the crop under communal production *(maruo)*;
WOMENSH = share of fields of the crop under women's control;
SIZEFLD = size of crop area in hectares;
DISTANCE = walking distance to field in minutes;
SINEUSE = multipurpose implement used (= 1, else = 0);
PLWUSE = plow used (= 1, else = 0);
SOIL = soil quality dummy within upland area (= 1 if fields close to border area [better soils], else = 0); and
JPSHARE = share of partly water-controlled land in project over total of tidal, rainfed, and traditional rice.

[b] As fully water-controlled rice production in the project does not involve the crop-specific area allocation choice (because of the rationed land distribution), a yield function was estimated for fully water-controlled project rice. Specification and estimation results are as follows:

$$\underset{(8.03)}{YIELD = 3{,}992.9} + \underset{(1.96)}{7.1197\ HAFERT} - \underset{(-1.83)}{0.0124\ HAFERTSQ} + \underset{(0.74)}{2.5229\ HALABWE} + \underset{(1.81)}{716.23\ SIZEFLD},$$

where YIELD = paddy yield in kilograms per hectare and HALABWE = weeding labor input in person-days per hectare.

The *average* opportunity cost of labor in the new rice fields (established by alternative use in upland crops and traditional rice) has already been defined by the gross margins per labor day in these crops. The estimated production functions are used to compute the *marginal* labor productivity for the various crops. It turns out that marginal returns to labor in upland crops (millet and groundnuts) were higher than in the new rice fields in the wet season of 1985/86 (Table 20). The related parameters in the production functions for the upland crops are largely robust and significant. Marginal labor productivity is lower than average productivity. Yet for the major field crops (groundnuts and upland cereals), it is still D4.60-7.50, or US$0.91-1.48 per day.

A diagnosed low overall marginal labor productivity in the fully water-controlled rice fields (Table 20)—despite high average labor productivity over the season—does not come as a surprise. Participating farmers are under considerable pressure to adhere to a strict schedule defined by the project's management. This stresses maximum yields rather than equating marginal returns with marginal (opportunity) costs of labor. Farmers not maintaining the set schedule, and therefore achieving "inadequate" yield levels, run the risk of being expelled from the project. Farmers with a very profitable dry-season crop in the fully water-controlled area are unlikely to take that risk. Also, the relatively safer pump-irrigated crop compares favorably with the upland crops in a drought year. From a farmer's perspective, however, and in economic terms, it would have been better to spend more time on the upland crops in 1985/86, given their higher marginal returns to labor. This coincides with a reported reluctance of some farmers to follow the schedules set by the project.

Implications for Irrigation Schemes

An attempt to maximize yields in irrigation schemes without due consideration of labor's opportunity cost is suboptimal both for farmers and for the economy. Irrigation schemes in this volatile environment are destabilized by the fluctuating labor supply as a

Table 20—Average and marginal labor productivity in major crops, wet season 1985/86

Crop	Average Labor Productivity in Gross Margin per Labor Day[a]	Marginal Labor Productivity Derived from Production Functions[b]
	(dalasi/person-day)[c]	
Upland cereals (millet, sorghum, and maize)	8.88	7.50
Groundnuts	8.70	4.61
Swamp rice	5.70	3.20[d]
Partly water-controlled rice in project[e]	7.40	3.20[d]
Fully water-controlled rice in project[f]	14.70	1.42[g]

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

[a] Gross margin (net return) is calculated as the difference between value of (marketable) output minus variable costs (including hired labor).

[b] The marginal labor productivity evaluated at respective mean values of labor input and average sales prices of output; for parameters, see Table 19.

[c] One U.S. dollar equals 5.06 dalasi.

[d] Traditional swamp rice and partly water-controlled rice in the project are dealt with in one model (Table 19).

[e] These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

[f] These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

[g] The parameter on which this value is based is statistically insignificant (see footnote b on Table 19).

consequence of changing returns to labor in competing crops from year to year, which is a function of rainfall quantity and distribution. A flexible response to this situation is required—one that cautiously permits yield fluctuations due to labor reallocation—not an attempt to either enforce constantly high labor input or maintain it by an excessive subsidy to irrigation. Neither is economically justifiable.

In addition, a flexible (economic) approach to yields, which permits the irrigation schemes to fluctuate between lower yields in years of good rainfall (when labor is pulled into upland crops) and higher yields in years of low rainfall, would introduce a buffer function for local- and household-level food security. In the 1984 drought year, the Jahally-Pacharr project in fact functioned that way. Making use of this food security potential of small- and medium-sized irrigation schemes calls for a wide distribution of irrigated land across the communities in order to permit a large number of compounds to resort to irrigated rice with rather stable and high yields, even though achieved at low marginal labor productivity in drought years.

Effects on Labor Allocation and Competition with Other Crops

Given the above patterns of average and marginal returns to labor in rice under new technology versus other crops, what are the implications for and effects on labor allocation? To address this question, a labor input model is specified, as discussed in the conceptual framework (Chapter 2, equation [3]).

Given various demographic characteristics, labor inputs to crops and to nonagricultural work are hypothesized to be determined by relative net returns to labor in the various alternative activities. Only some of these basic relationships can be adequately captured in this cross-sectional analysis. Actual crop prices and farmers' price expectations are excluded because of the cross-sectional nature of the data. The main focus of the labor input analysis is to quantify the effect of access to project rice land on labor inputs to *other* crops. Household demographics are assumed to play a role here, as some ethnic and gender specificity of labor allocation by crop occurs. In addition, the project's labor-saving capital equipment may affect the degree of substitution between the new rice crop and other crops grown before. The crop-specific and aggregate labor input functions have the following formula:

$$LAB_{ji} = f(DEM_{ji}, LOC_i, CAP_i, RLAN_i), \qquad (12)$$

where

LAB_{ji} = total labor input in person-days (paid and unpaid labor) for crop j by farm i,

DEM_{ji} = a set of demographic variables (household size, children, women's share),

LOC_i = distance from project in terms of location of village in upland or lowland,

CAP_i = value of agricultural machine and implement capital stock per adult-equivalent person, and

$RLAN_i$ = size of area in the rice project per adult equivalent (in fully water-controlled equivalent area).

The results are presented in Table 21. The model further supports the impression from earlier tabulations that with increased availability of rice land in the project, total

Table 21—Reallocation of labor between crops: regression results

Explanatory Variable	Family Labor in All Crops		Family Labor in Upland Cereals		Family Labor in Groundnuts		Family Labor in Swamp Rice	
	Parameter	t-Value	Parameter	t-Value	Parameter	t-Value	Parameter	t-Value
Size of compound in adult equivalents	46.507	17.13	8.281	8.17	15.129	10.37	18.342	9.48
Number of children under 10 per adult equivalent	−331.021	−3.51	−58.359	−1.62	−117 043	−2.12	−72.728	−1.00
Ratio of women per adult equivalent	60.012	0.50	−47.990	−0.95	−71.842	−0.94	184.418	2.17
Location of village (1 = lowlands, 0 = uplands)	−27.989	−0.76	−68.134	−4.93	−141.641	−7.09	138.591	2.60
Machine and implement capital per adult equivalent (dalasi)	0.6672	0.72	0.2039	0.56	−0.3096	−0.62	0.4041	0.61
Amount of land in project per adult equivalent (hectares)[a]	−942.980	−1.71	−684.048	−3.18	−1,045.305	−3.04	−855.950	−2.20
Constant	200.940	3.00	157.716	6.04	227.238	5.88	−150.904	−2.28
$\bar{R}^2$	0.614		0.429		0.556		0.508	
F-value	55.990		24.780		38.540		18.730	
Degrees of freedom	202		184		174		97	

Note: Dependent variables—family labor input in person-days by respective crop at compound level, except in the case of large Wolof and Mandinka compounds, where subcompound units are used.

[a] Land expressed in "fully water-controlled equivalent" on yield basis.

labor input in agriculture is decreased rather than increased. The estimated parameter (Table 21, column 1) of −942.98 suggests that if an average compound obtains an average portion of project land (0.43 hectare), total labor inputs to agriculture are reduced by 28 days per compound, or 7.5 percent of total wet-season labor. Note that the parameter is not of high statistical significance. From the above tabulations, it was evident that it was more male than female labor input that was reduced overall (see Table 14).

More significant than this labor-input-reducing effect, which could include a "leisure effect" arising out of the income effect of the more profitable new rice fields, are the labor substitution effects to the various crops. Evaluated at the respective sample means, given access to an average piece of project land, total labor to swamp rice is reduced by 21 percent; to upland cereals, by 19 percent; and to groundnuts, by 22 percent. Clearly, the competition between labor for the new rice and labor for the upland crops and traditional rice is strong.

The opportunity cost of labor in the project has profound implications for the net benefits of technological change and its related investment. The reduction in upland cereals and groundnuts due to reduced labor allocation to these crops is crucial. The output volume of the principal nonproject crops was reduced by 19.4 percent for an average compound (Table 22). The gross income forgone due to reduced crop production outside the project amounts to D636 per compound or compound subunit in the large Wolof or Mandinka compounds.

In terms of each ton of incrementally produced paddy, this output forgone in other crops is equivalent to 161 kilograms of upland cereals, 112 kilograms of swamp rice, and 204 kilograms of groundnuts. For every incremental D100 earned in the new rice production in the wet season, D64 are lost from other crop production.

To sum up insights from this chapter, staple food supply *is* increased to the households, but at considerable cost. These costs consist of investment costs and direct operating costs in the project, and of output forgone in the other crops from which labor was withdrawn. This last cost component is frequently overlooked. The challenge for program and project design and management is to select and promote technologies at the microlevel that will enhance labor productivity. A simple focus on a high and

Table 22—Opportunity cost of project rice and production forgone from other crops due to project

Forgone Income/Production	Change per Compound[a] Upland Cereals	Swamp Rice	Ground-nuts	Total Weighted Average
Gross income forgone (at average net returns per person-day, in dalasi)[b]	246	194	383	636
Crop production forgone				
Kilograms/compound[c]	289	201	368	. . .
Percent of 1985 production of each crop	19.3	38.0	17.5	19.4

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

[a] Average compound at sample means.

[b] Computed on the basis of the gross margin computation (Table 16) and the labor input functions (Table 21).

[c] Computed on the basis of the production functions (marginal labor productivities: parameters of HALAB, HALABSQ) and the labor input functions (Tables 19 and 21).

stable output per unit of land can easily be misleading in this West African environment. A flexible approach to yields in such irrigation perimeters is required, guided more by overall economic considerations and less by ease of project management. This would make optimal use of scarce farm labor but would not respond with excessive subsidies or enforcement of power when labor follows economic incentives and turns away from irrigated rice in years of good rainfall that enhance returns to labor in the uplands.

5

EFFECTS ON MARKETED SURPLUS, STORAGE, AND INCOME

For a complete assessment of the effects of new agricultural technology on different population groups, an analysis of the demand-side effects of the increased output is as important as one for the supply-side effects. This chapter, therefore, evaluates the effects of technological change and commercialization on marketed surplus and income, while the following chapter considers the consumption of food and nonfood resources.

Marketed Surplus Effects

Cereals produced by the household are used for a variety of purposes. On the disappearance side of the balance, sales for cash are only one among many transactions, some of which constitute in-kind payments. Among these in-kind transactions are loan repayments, payment for hired labor and the renting of tools, and various types of gifts and donations. A broadened view of "marketed surplus" is required in this social environment, where gifts and donations form a large part of transactions related to a complex system of social security. Gifts may take the form of goods traded against services and may also be "true" charitable donations, bearing in mind that there is a strong obligation in this society for the receiver to repay "gifts" whenever the giver falls into a time of need (Mauss 1954).

The various uses of a harvest differ a great deal between crops and types of technologies of crop production. In the case of rice, the highest share (about 20 percent) of cash sales is observed for the swamp rice (Table 23), while only 7-12 percent of project pump-irrigated rice was sold. Thus, an inverse relationship between levels of output per unit of land and labor and percent of marketed surplus of rice is observed here. This has little to do with technology as such, deriving instead from the institutional arrangements under which each crop is produced. As discussed above, rice in the project is largely a communal crop, of which little is sold. Swamp rice, on the other hand, is a women's crop grown partly for food and partly for cash income. Similarly, very little is sold of the upland cereals (millets, maize), which are also largely grown as communal crops.

The importance of the institutional arrangements is particularly significant for the rice crops: 80 percent of swamp rice cultivated as *maruo* was actually consumed in the *sinkiro*, compared with only 58 percent of the *kamangyango* swamp rice. Similarly, we find that from the partly water-controlled rice in the project, 45 percent was retained for consumption when grown as *maruo*, but only 19 percent when grown as a *kamangyango* crop in 1984/85.

Rice cultivation in the project involves loan repayments for inputs and water charges. In 1984 these amounted to 30.1 percent of total output, but they dropped to 18.3 percent in 1985 in the fully water-controlled rice. The drop was due to upwardly adjusted output prices applied to the per-unit-of-land repayment duties. This portion of "marketed surplus" required for loan repayment is a quota and not a choice variable on the part of the farmers. Nevertheless, from a sectoral perspective it still indicates an increased commercialization of agriculture. After the disposal components of loan

Table 23—Uses of harvest, by crop and rice technology, 1984 and 1985 wet seasons

Use	Rice								Early Millet, Sorghum		Maize		Groundnuts	
	Fully Water Controlled in Project[a]		Partly Water Controlled in Project[b]		Pump Irrigated in Old Schemes[c]		Swamp							
	1984	1985	1984	1985	1984	1985	1984	1985	1984	1985	1984	1985	1984	1985
	(percent of total production of each crop)													
Loan repayments	30.1	18.3	34.2	27.2	5.7	4.4	0.4	0.8	0.0	0.2	0.4	0.0	2.5	1.7
Hired labor and rents[d]	1.4	0.7	1.6	2.7	3.1	2.5	2.6	1.5	0.4	0.3	0.1	0.2	0.4	1.2
Gifts, donations	6.5	9.4	5.8	10.7	9.3	11.5	10.7	15.4	10.4	12.7	13.1	12.5	3.5	2.4
Sale[e]	7.3	12.2	15.5	6.9	8.2	2.1	19.1	20.7	2.9	0.9	3.6	1.8	71.1	65.7
Consumption[f]	54.7	60.2	42.9	52.5	73.7	79.5	67.2	61.6	86.3	85.9	82.8	85.5	22.5	29.0

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

[a] These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

[b] These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

[c] These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.

[d] For implement rentals (in-kind repayments).

[e] Including harvest given as loans for later payment (0.1-0.4 percent per crop) and exchanged in kind (barter, 0.0-0.2 percent per crop).

[f] Including retained seed (1.3-5.4 percent of cereals, 10.9 percent of groundnuts) and storage losses, which are negligible on average.

repayments and some project cost recovery (the "water charges") are accounted for, the share of project rice marketed is smaller than that of swamp rice.

Nevertheless, the proportion of all rice marketed is generally higher than that of coarse grains (Table 23). Nearly all of the coarse grain produce stays in the compound, apart from donations, of which the traditional charity donation called *zakat* (a decile of the harvest) forms the largest share. Fluctuations in domestic household cereal supply and in demand (stemming from seasonal and interyear fluctuations in coarse grain production) are largely leveled out by transactions in rice. Thus it is the rice market in rural areas that equates effective demand with the general supply of cereals. In the 1984/85 year of drought and trade-determined cereal shortfalls, the marketed surplus of millet was slightly higher than in 1985/86. Yet, even in upland villages that concentrate on millet production, sales did not exceed 7 percent of total output.

In general, women farmers sell a higher share of rice produced under their control than men in the same rice technology (Table 24). Women use rice as a means to raise cash for the purchase of, for example, cooking ingredients, which are important female expenditure items. Rice sales from stocks are frequently carried out in small quantities "by the cup."[25] In the wet (hungry) season when most compound stocks are low, these sales are important both for the sellers (who raise cash for the purchase of ingredients) and for the purchasers. The latter are particularly short of cash during the hungry season, and they bridge this period with short-term purchases tailored to the specific circumstances of the household's ability to purchase and the timing of the first September grain harvests (roasted fresh maize cobs, fire-dried early millet).

Most by-the-cup selling is done by women. On average, women in the sample sold 2.6 kilograms of rice per week in this invisible market in the wet season. These sales correspond to 9 kilograms of paddy per *sinkiro* per week in the 55 percent of *sinkiros*

Table 24—Shares of rice harvest retained for consumption and sold, by technology and sex of farmers, 1984 and 1985

Use	Fully Water-Controlled Rice in Project[a]			Partly Water-Controlled Rice in Project[b]		Pump-Irrigated Rice in Old Schemes[c]			Swamp Rice	
	1984	1985		1984	1985	1984	1985		1984	1985
	Wet Season	Dry Season	Wet Season	Wet Season	Wet Season	Wet Season	Dry Season	Wet Season	Wet Season	Wet Season
	(percent)									
Retained for consumption										
Men	54	58	59	72	61	81	67	71	62	68
Women	51	55	60	32	51	61	75	82	64	61
Sold										
Men	7	7	11	...	7	3	10	5	16	15
Women	7	9	19	18	7	12	5	0	18	21

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Note: Other uses of the harvest are not included; therefore, figures do not add up to 100 (see Table 23).

[a] These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

[b] These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

[c] These fields are in the former World Bank and Chinese schemes. They are partly irrigated with small pumps.

[25] Standard-sized tins are used for measurement. The most frequently used tin holds about 250 grams of white dehusked rice.

reporting such sales. Most of these *sinkiros* (80 percent) are in lowland villages and these sales stem largely from the dry-season crop cultivated in the fully water-controlled part of the Jahally-Pacharr project. The irrigated dry-season crop serves to even out the most severe seasonal scarcities in cereal availability. The by-the-cup sales between July and September add up to about 8 percent of the dry-season paddy harvest.

The effects of the new rice technology and the heterogeneity of cereal sales by type of farm household become more apparent if the sample is divided by lowland and upland villages and by degree of access to new project rice fields. Generally, the more the involvement in the project, the more sales of rice increase as a proportion of production (Table 25). Among compounds with a high degree of involvement in the project, the share of sales from women's swamp rice increases even more than the

Table 25—Shares of marketed surplus and own consumption of crops, by access to project rice fields, wet season 1985

	Access to Rice Fields in Lowland Villages				Access to Rice Fields in Upland Villages			
Crop	Lowest Quartile	Second Quartile	Third Quartile	Highest Quartile	Lowest Quartile	Second Quartile	Third Quartile	Highest Quartile
	(percent of production of each crop)							
Rice								
Fully water controlled in project[a]								
Sales	8.8	5.1	10.8	17.5	4.1	4.3	4.5	0.0
Loan repayment	25.3	17.8	17.0	15.3	17.8	18.5	25.4	25.6
Own consumption	48.4	59.5	58.5	53.8	70.6	64.3	58.5	66.7
Partly water controlled in project[b]								
Sales	6.2	7.5	5.0	8.5	3.5	4.6	c	c
Loan repayment	17.0	22.2	28.1	31.3	26.6	25.6	c	c
Own consumption	62.7	58.2	47.5	40.7	58.4	57.0	c	c
Swamp								
Sales	15.2	18.5	24.0	29.2	8.2	0.0	c	c
Own consumption	57.9	54.5	51.0	51.8	78.7	79.5	c	c
Early millet								
Sales	1.4	0.0	0.0	0.0	1.3	7.0	4.3	c
Own consumption	80.5	88.6	84.5	76.8	84.9	82.5	71.0	c
Late millet								
Sales	c	0.0	0.0	c	7.5	c	c	c
Own consumption	c	88.0	87.0	c	69.4	c	c	c
Sorghum								
Sales	0.0	0.0	0.0	c	0.0	0.0	0.0	c
Own consumption	79.0	90.0	86.5	c	86.9	87.8	76.4	c
Maize								
Sales	8.8	3.5	0.0	0.0	3.3	1.8	0.9	0.0
Own consumption	48.4	70.5	67.7	67.1	86.2	78.3	76.7	82.9
Groundnuts								
Sales	65.0	65.3	51.6	55.1	68.7	63.8	[illegible]	51.5
Own consumption[d]	21.5	27.8	39.9	35.1	25.8	30.7	[illegible]	42.4

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Notes: The quartiles are defined in terms of fully water-controlled area per adult-equivalent person in the *sinkiro* and are formed equally for the whole sample. Thus, for instance, the second quartiles in both upland and lowland villages are formed of *sinkiros* of the same quantity of land per adult equivalent on average.

[a] These fields are in the pump-irrigated perimeter of the project. They produce two crops a year.

[b] These fields are in the tidal-irrigated perimeter of the project or are purely rainfed. Some of them produce a crop in the dry season, but most produce only one (wet season) crop a year.

[c] No observation.

[d] Own consumption includes storage of seed intended for use in the next season, which is a sizable share of these groundnuts.

sales from the project rice. These tendencies come out clearly among the lowland villages, which were traditional rice tillers before the project.

Groundnuts are both a cash and a subsistence food crop. In the lowland villages, and in households with considerable access to new rice fields, 35-40 percent of groundnut production is retained. This traditional cash crop—reduced in area and output due to labor reallocation to rice—is more of a subsistence food crop in such households, while rice has become more of a cash crop. The variable pattern of crop use within the sample, given different family and farm characteristics, underlines the limitations of the simplifying terms "subsistence food crop" and "cash crop." These tendencies are similar in upland villages, although very little of the rice is sold in them (Table 25).

Increased market integration of agriculture is inseparable from rural development, which exploits the benefits of specialization in an expanding agricultural sector and rural economy. The above analysis highlights the complex patterns of cereal markets at the local and compound levels. Economic factors, environmental conditions, and institutional forces all influence the marketed surplus ratio of cereals. Increased output achieved through technological change in one crop does not lead to a straightforward expansion of marketed surplus. Substitution effects in production and increased consumption—desired from a nutritional perspective by many families—reduce the expected marketed surplus effects of output growth in the new rice crops. A model is used below to further evaluate the roles played by factors that shape the gross marketed surplus of cereals. The model analysis focuses on the effects of increased cereal production for sales of grain and on its short-term price elasticity (see also the conceptual framework in Chapter 2, equation [5]).

The dependent variable in the model is the quantity sold of all cereals (CERSOLD). The cereal quantities are expressed in milled equivalents out of the sum of millet, sorghum, maize, and rice. The model is specified following the hypotheses below.

It is hypothesized that an increased supply of cereals from own production (CERPROD) increases the marketed surplus. While this is certainly the case once household demand is fulfilled (accounted for by size of compound, SIZE), this demand itself can be assumed to be income-elastic. This is accounted for by the per capita income variable in the model (INCOME) approximated by the total expenditure value (cash and in kind) per adult-equivalent person.

From an increased price, an increase in marketed surplus is expected. Because of the dominance of rice in equating supply and demand on the cereals market, and the close correlation with other cereal prices, the rice price (PRICE) is used as the only price variable in the model. Price variability in the cross-sectional sample covering the 1985 season is substantial. This variability stems from local differences in linkages to market outlets and intraseasonal differences that are not independent of demand from across the border (to Senegal) as well as the related exchange rate differences that impinge on the dalasi price. To avoid disturbances in the price variable due to household-specific differences in sales timing (for instance, the poor may be selling earlier in the season at a lower price), village mean prices are used in the model. The logarithm of the price is used, assuming that the price elasticity of marketed surplus is diminishing for larger price changes.

The scope for price policy to stimulate marketed surplus at current levels of infrastructure is of interest for policy analysis purposes. Infrastructure is therefore controlled for in the model with the variable depicting distance to the main markets from each village (DISTANCE). This distance variable is included because time and transport costs to compounds that sell in bulk may not be fully captured by the village-level prices. A potential endogeneity problem arises where local prices are partly a function of infrastructure, yet the other factors leading to village-specific price variability are also important. The potential endogeneity of prices is certainly an issue that calls for further research in these complex market environments of West Africa.

Given the dominance of rice in the grain market, an increase in the share of rice production in total cereal production (RICESH) is expected to result in an increase in the marketed surplus of all cereals. The model is, therefore, composed of

$$CERSOLD_i = f(CERPROD_i, RICESH_i, \ln PRICE_i, DISTANCE_i, INCOME, INCOMESQ, SIZE, SIZESQ). \quad (13)$$

(For details of variable definitions, see Table 26.)

The estimation results are given in Table 26. They suggest a significant positive elasticity of marketed surplus for supply and for price. Evaluated at sample means, a 10 percent increase in cereal production increases sales by 8.4 percent. A 1 percent increase in the (rice) price would increase sales by 2.9 percent, which appears to be a rather high price elasticity. Given the cross-sectional nature of the analysis, a cautious interpretation of this price elasticity is suggested. One certainly would like to assess

Table 26—Marketed surplus model for cereals: regression results

Explanatory Variable[a]	Parameter	t-Value	Mean of Variable
CERPROD	0.0701	5.89	2,401.63
RICESH	344.7470	5.50	0.57
lnPRICE	621.1690	1.91	−0.07
DISTANCE	−25.4168	−2.80	3.31
INCOME	0.0273	0.32	1,344.55
INCOMESQ	−1.8905E−6	−0.10	2,122,666.40
SIZE	0.3315	0.05	9.37
SIZESQ	−0.0876	−0.44	123.41
Constant	−46.208	−0.38	. . .
$\bar{R}^2$	0.430		
F-value	18.55		
Degrees of freedom	200		

Notes: Dependent variable—cereals sold (kilograms of all cereals in milled equivalent per compound). The mean value of the dependent variable, CERSOLD, is 201.1 kilograms. The unit of observation is the compound or, in the case of some large compounds, the subunit (*sinkiro*—a cooking and consumption group).

[a] Definitions of variables:

CERPROD	cereals produced in wet season 1985 per compound (kilograms of all cereals in milled equivalent);
RICESH	share of rice in total cereal production, wet season 1985;
lnPRICE	rice price in dalasi/kilogram (logarithm of village mean price);
DISTANCE	distance to main market from each village;
INCOME	total expenditure (as income proxy) per adult-equivalent person for 1985/86 (in dalasi);
INCOMESQ	income squared;
SIZE	size of compound in adult-equivalent persons; and
SIZESQ	size squared.

the marketed surplus-price relationships more closely with a dynamic model, which the data, however, do not permit. Marketed surplus shrinks with increased distance from the market place by 13 percent for every kilometer, other things held constant. The critical role of market infrastructure for market integration is highlighted by this estimation result. An increased share of rice production in total cereal production expands marketed surplus beyond the total cereal supply of the compounds. Compounds with a higher share of rice in their total cereal supply become more market-integrated as sellers (and buyers) of cereals: a 10 percent increase in the rice share leads to a 17 percent increase in marketed surplus. Thus the new rice project enhances market integration as the supply share of the most marketable cereal expands and total supply increases. Neither the income-related nor compound size-related variables show up significantly in the model.

Effects on Storage and Storage Control

Cereal storage in the compounds involves different institutional rules. The various subdivisions of the compound may or may not maintain different storage places in which their grain stock is kept under their control. The storage place of each stock is institutionally defined by the mode of production under which it was cultivated (communal or individual). The right to extract produce from these various stocks lies with the individuals or subgroups in charge of the specific storage space.

Most storage locations (47 percent) are found under the control of the compound head. Personal storage by other individuals is also widespread (28 percent of stores). Eight percent of the stores were defined as *sinkiro* (cooking unit) stores, 8 percent as *dabada* (working unit) stores, and 9 percent as other stores. Individually controlled stores usually hold only small quantities for sale to cover personal expenses. About two-thirds of all cereals stored are under the control of the compound heads. Despite remarkable fluctuations in volume stored by season, this share remains fairly constant (63 percent in the wet season and 65 percent in the after-harvest dry season when total storage is nearly four times the wet-season quantity). Women were in charge of only 15 percent of cereal stocks in the dry season (storage was assessed in February 1986), but they held about one-third of the stored rice.

The crop composition of cereal storage changes substantially between seasons. Rice made up about 90 percent of stocks held by the sample households during the wet season and 41 percent in the dry season. The remaining stocks were made up of coarse grains.

The pronounced seasonality of Gambian agriculture and food availability shows up clearly in per capita storage levels. During the hungry season an average of 16 kilograms was held in store, while in the dry season the average was 64 kilograms. The dry-season crop from the scheme obviously smooths out the seasonal differences. The overall figure for the wet season is, therefore, not representative for the country or comparable environments in the region.

This is more the case when considering the group with no or very little access to the rice project. The quartile of compounds with least access held only 4 kilograms of cereals per capita in the hungry season, compared with 29 kilograms in the top quartile. On the other hand, in the dry season 100 kilograms per capita were held by the bottom quartile versus 61 kilograms by the top. Compounds with little dry-season rice production attempt to bridge the hungry season with higher opening stocks of coarse grains from wet-season production.

Storage levels vary little by income in this setting. At the low and high storage points, the poor have about as much in stock as do the upper income quartiles. Table 27 shows this for the 75 compounds that have little or no access to the Jahally-Pacharr project. These numbers are, therefore, not much affected by the dry-season irrigated rice production. Equally low storage levels of 5-7 kilograms per adult-equivalent person in the wet season in the compounds across all income groups do not mean, however, that consumption levels are similarly uniform. This is discussed in Chapter 6.

It should be noted that averages cover variability in the storage figures. Many of the compounds with little access to dry-season rice fields have totally depleted their stocks by the middle of the wet season and survive on the basis of almost daily by-the-cup purchases of rice. Even brief disruptions in the ability to acquire food (rice) in that period of the year may result in acute food consumption shortfalls. The increased storage levels due to rice from the project in this critical period of the year certainly improve household-level food security. It is not only the average annual increase of output due to new production technology that matters in this setting, but also the seasonal timing and reliability of it. Respective aspects of these considerations are further evaluated in the following analysis on income effects.

Income Effects

The analysis of agricultural production effects of the new rice technology showed an increase in labor productivity. This is expected to translate into increased per capita income and consumption. The analysis in this section evaluates (1) the pattern and seasonal change in income sources and the role of increased rice income in this context, and (2) the effects of the new technology on distribution of income.

The analysis is based on a complete income accounting carried out for the two periods covered by the survey. Season 1 covers March-August 1985, and Season 2 covers September 1985-February 1986. Thus, Season 1 includes the dry-season crop income and Season 2, the wet-season crop. In both seasons, livestock income and income from off-farm work, craft work, and trading as well as income transfers (remittances) are accounted for. For this analysis the income data were collected at the individual level in the compounds and then aggregated at the compound or compound subunit level where applicable. Table 28 gives a breakdown of the income accounts by upland and lowland villages.

Table 27—Seasonal cereal storage in compounds outside the project, by income group, 1985/86

Season	Income Groups[a] Lowest Quartile	Second Quartile	Third Quartile	Highest Quartile
	(kilograms of stored cereals/adult equivalent person)			
Wet[b]	4.6	4.6	5.0	7.0
Dry[c]	80.8	58.7	95.1	102.2

Source: Computed from 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.
[a] Total expenditure per year per adult equivalent person is used as an income proxy.
[b] In August/September 1985.
[c] After harvest (March 1986).

Table 28—Income in upland and lowland project villages and nonproject villages, by source, 1985/86

Income Source	Lowland Project Villages	Upland Project Villages	Villages Outside Project	Total Average
	Income per Adult Equivalent			
	(dalasi)			
Season 1 (March-August 1985)				
Rice	123	46	40	87
Animals	-5	-4	-7	-5
Vegetables	3	1	10	3
Total own agriculture[a]	120	42	43	85
Total off-farm	113	61	104	95
Total income (Season 1)	233	103	146	180
Season 2 (September 1985-February 1986)				
Rice	237	60	64	157
Millet, sorghum, maize	62	248	86	127
Groundnuts, cotton	95	300	151	171
Animals	-8	11	-3	-1
Vegetables	9	13	29	13
Total own agriculture[a]	389	625	322	460
Total off-farm	71	58	65	66
Total income (Season 2)	459	683	387	526
Total annual income	692	786	533	706

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.
Note: Parts may not add to totals because of rounding.
[a] Cost of tools is deducted here.

Average per capita income was US$116 per year (at a parallel exchange rate). The average of the highest income quartile was only 3.7 times the average of the lowest (Table 29). However, the notion of homogeneous poor peasants would be grossly misleading. Although most of the income earned is from own agricultural production (77.5 percent), income from other sources is not negligible. Average nonagricultural income stands at 22.8 percent, but it is 25.8 percent in the top quartile versus 20.4 percent in the bottom. In Season 1 (March-August), nonagricultural income is more important than agricultural earnings, particularly among the poorest. Income from animal production was on average negligible at the study site in 1985/86. This may be due to low prices in the drought year 1984/85, animal losses, and low sales volume in 1985/86.

In the lowest income quartile, the seasonality of the income flow is most pronounced: 80 percent of income is earned in the second season, while it is 72 and 75 percent in the two upper quartiles. Season 1 and Season 2 income is significantly correlated. In other words, the poor are poor in both seasons. Consequently, annual income correlates significantly with hungry-season income with a correlation coefficient of 0.48.

Rice production (including rice for own consumption) is a major income source in the sample compounds. An average of 34 percent of total annual income derives from rice, yet the importance of rice for income varies widely. In compounds from villages outside the project, rice production generates only 20 percent of total income (Table 28). This situation may be comparable to the preproject situation, since the two study villages outside the project are lowland communities with swamp rice and some old-scheme rice production. In the lowland villages of the project, rice (from all sources) now contributes 52 percent of income, while it is 13 percent in the upland villages

Table 29—Main income sources, by level of per capita income, 1985/86

Income Source	Per Capita Income Groups: Lowest Quartile	Second Quartile	Third Quartile	Highest Quartile	Total Average
	(percent of annual income)				
Season 1 (March-August 1985)					
Own agriculture	7.3	12.5	15.6	10.7	12.1
Off-farm work and transfers	12.8	12.7	12.5	14.6	13.5
Total	20.2	25.2	28.2	25.3	25.6
Season 2 (September 1985-February 1986)					
Own agriculture	72.2	66.4	64.0	63.4	65.4
Off-farm work and transfers	7.6	8.3	7.8	11.2	9.3
Total	79.8	74.8	71.8	74.7	74.8
Total annual	100.0	100.0	100.0	100.0	100.0
Total annual income per adult equivalent (dalasi)	327	568	767	1,147	703
Total annual income per adult equivalent (US$)[a]	65	112	152	227	139
Total annual income per person (US$)[a]	64	93	127	189	116
(Number of observations)	(55)	(56)	(56)	(57)	(224)

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.
Note: Parts may not add to totals because of rounding.
[a] Converted at parallel exchange rate (US$1.00 = 5.06 dalasi).

(new tillers). In the top quartile of compounds with the most access to new rice fields, rice provides 67 percent of annual income. This is also the group with the least seasonal fluctuation of income due to the fully water-controlled technology, which ensures an income source in the hungry season.

Rice production has relatively greater importance for the poorest farmers (43 percent of income) than it has for the top income quartile (26 percent). The new rice technology has contributed—at least in the short run—to a more equal distribution of income in the area. The households that would benefit most from further improvement in labor and land productivity of rice are those currently earning a high share of their income in rice, and this is relatively more the case for the poorer households. This also means that any deterioration in yields in the project would most adversely affect poorer households.

Determinants of Income Differences

The causes of income differences in rural West Africa do not lend themselves to easy conceptualization. Socioanthropological determinants, such as status, lineage, and ethnicity, which determine access to and control over resources, play a major role and interact with more general economic factors, such as acquired human capital and the capital stock for agricultural production (tools, livestock) (Hill 1970, Meillassoux 1981). An attempt is made below to identify the factors that determine income differences in this area through an income-earning model and to assess the incremental role of access to new rice technology in this context (see also conceptual framework, Chapter 2, equation [6]).

The following hypotheses underlie the multivariate analysis. The main factor of production in all income-earning activities in the area is labor. The size and demographic composition of a compound (size of work force, share of women and children, age of compound head) is crucial for its income earning. Endowment with human capital is difficult to assess in this environment, where almost invariably a few years of Koranic school training is obtained by the heads of the households. Yet, acquired skills in craft work are of importance and are included in the model. Where production is concerned, agricultural income—the main income source—is hypothesized to be determined (beyond labor) by agricultural capital (that is, labor-saving equipment and the size of livestock herds). Access to project land can be interpreted as a capital asset, too. It is included to test for its effects besides the other factors mentioned. The model also tests whether a higher share of communal agriculture *(maruo)* reduces efficiency—a compound labor force might be more concerned with its private fields—and thereby the per capita income of compounds. Finally, the effect of ethnic differences (that is, Serahuli who are more involved in craft work and trading) was tested, and whether compounds residing longer in the area do better. The model is thus specified as follows:

$$INCOME_i = f(HHDEMO_i, QUALJOB_i, AGCAPITAL_i, MARUOSH_i, FOUNDED_i, SERAHULI_i, LOCATION_i), \quad (14)$$

where

$INCOME_i$ = income per capita (adult equivalent) in dalasi per year (1985/86);

$HHDEMO_i$ = compound size and demographics (see variables WORKPERP, CHLDAE, WOMENSH, AGECH in Table 30 notes);

$QUALJOB_i$ = human capital-related variable (qualification as craftsman);

$AGCAPITAL_i$ = agricultural capital-related variables (see AGTOOL, ANIMUNIT, NEWRICE in Table 30 notes);

$MARUOSH_i$ = share of land under communal crops in total crop land;

$FOUNDED_i$ = if compound was founded long ago (>10 years) = 1, else = 0;

$SERAHULI_i$ = if compound is Serahuli = 1, else = 0; and

$LOCATION_i$ = if compound is in lowland village = 1, else = 0.

The estimation results of this income-earnings analysis are presented in Table 30. From the model results, four points should be highlighted:

1. On the average, an additional plot of new rice land allotted to a compound significantly increases per capita income by D92 per adult-equivalent person per year. This is equivalent to 13 percent at the sample mean.[26] That this is a fairly stable and reliable income increase is noteworthy. This result for the net income effect appears to be consistent with the earlier findings of major substitution effects (labor) between crops in compounds with access to new rice land (Chapter 4).

[26] One plot equals 0.5 hectare divided by 9.2 adult-equivalent persons (per compound or compound subunit) multiplied by the parameter value of NEWRICE (1,088.5), which is on a per hectare basis.

Table 30—Determinants of income differences and the role of new rice technology for income

Variable[a]	Parameter	t-Value	Mean of Variable
WORKPERP	6.913	1.15	5.78
CHLDAE	−333.641	−3.77	0.57
WOMENSH	−81.822	−0.67	0.51
AGECH	−69.591	−2.37	6.12
QUALJOB	290.364	2.83	0.14
AGTOOL	232.336	3.61	0.29
MARUOSH	48.242	0.54	0.59
ANIMUNIT	44.986	3.62	1.29
NEWRICE	1,688.496	3.39	0.06
FOUNDED	57.857	1.25	0.69
SERAHULI	249.633	2.43	0.05
LOCATION	13.362	0.22	0.44
Constant	973.386	4.84	. . .
$\bar{R}^2$	0.256		
F-value	5.75		
Degrees of freedom	200		

Notes: Dependent variable—annual income per adult equivalent. Mean value of dependent variable, INCOME, is 705.03 dalasi. Unit of observation is the compound or, in the case of some large compounds, the subunit (*sinkiro*—a cooking and consumption group).

[a] Definitions of variables:

WORKPERP = persons in working age present in compound;
CHLDAE = ratio of number of children under 14 years of age over adult-equivalent persons;
WOMENSH = share of women in WORKPERP;
AGECH = age of compound head (age groups 4 . . . . 7);
QUALJOB = ratio of number of persons with special skills over WORKPERP (for example, craftsmen, healers);
AGTOOL = dummy = 1, if access to multipurpose tool for weeding and other purposes;
MARUOSH = share of communal land in total land use of compound;
ANIMUNIT = number of animals per adult person (animals converted to cattle equivalents on value basis);
NEWRICE = amount of land in the rice project in hectares per adult equivalent (land in fully water-controlled equivalents);
FOUNDED = dummy = 1, if compound was founded more than 10 years ago;
SERAHULI = dummy = 1, if ethnic group is Serahuli; and
LOCATION = dummy = 1, if lowland village.

2. An increased share of persons with specific skills for nonagricultural income-earning significantly increases per capita income (QUALJOB).

3. Accessibility of labor-saving tools (AGTOOL) increases per capita income, all else remaining the same, by 34 percent; the livestock effect for income is significant but not very large in terms of proportion to income (D45 per cattle unit); and increased share of communal agriculture does not appear to reduce per capita income (MARUOSH).

4. Over and above the discussed determinants of income, compounds in upland villages do not have significantly different income levels from those in lowland villages, but it is found that the Serahulis are significantly richer than the rest of the sample's ethnic groups.

Effects at Intrahousehold Level

In view of the very heterogeneous economic situation within the compounds, the distributional effects of the new technology should be considered not only at the aggregate household level, but also at the intrahousehold level. Considerable attention has been focused on the issue of intrahousehold resource distribution in recent years, following a growing recognition that neither poverty nor development interventions affect all members of the household uniformly (Lele 1986, Folbre 1986, Haaga and Mason 1987). There is a practical concern that project and policy initiatives that raise overall household incomes may at the same time be the cause of shifts in patterns of intrahousehold resource allocation that result in a negative effect on certain individuals. This concern relates primarily to the differential effect of changes on women versus men, and on different age groups within the household (Due 1987).

As was described earlier, compounds are stratified internally by various age/sex/status hierarchies, and may also be divided into subunits that operate on a semiautonomous basis. The benefits and burdens of technological change and commercialization can, therefore, be spread very differently among these various groups.

For example, it has already been emphasized that the introduction of the new rice production technology led to a transformation of the status of the crop: traditionally a women's crop grown to a large extent on private farms, it became mainly a communal crop under the authority of the male compound head. Yet this transformation in the status of rice involved more complex changes in the system at the intrahousehold level than a simple switch from a woman's to a man's crop. The reassignment of rice as a communal crop has (1) led to an increase in the burden of communal agricultural work for both men and women, but relatively more for women; (2) reduced the opportunity for women to grow rice as a private cash crop; and (3) resulted in an increasing centralization of authority in the compound head, manifested primarily in his newfound control over the rice crop (von Braun and Webb 1989).

The designation of project rice as a full-fledged communal crop has meant that the labor demands of communal farming as a whole have increased substantially in absolute terms. The burden of communal labor has therefore increased for both men and women, relative to the burden of private agriculture. Yet in this shift, the women's share of work in communal agriculture has risen relatively more than the men's. At the same time, the swamp fields, which women formerly cultivated with traditional rice (largely as a mixed private and communal crop) were much reduced in favor of the new rice plots. Both of these changes have led to a reduced ability of individual farmers (especially women, but also some junior male compound members) to maximize individual profit as private farmers and to a resultant centralization of power in the hands of senior male compound members.

This is not to imply, however, that women are necessarily dispossessed of all individual farming rights or of an independent income. It was shown in Chapter 4 that women organize private production of upland cash crops, such as groundnuts and cotton. In addition to this upland income, many women are also paid by the compound head for work that they carry out in the new project rice fields. Table 31 shows that payments ranging from 0.08 to 2.58 kilograms of rice have been given to women for each day of work that they spend in the communal project fields. The variability of payments by village is dictated by the extent to which those villages were formerly involved in swamp rice production and by the amount of swamp rice land still available for cultivation to the women in the various communities. (For example, of the eight project villages, Pacharr has the largest amount of swampland still available to its women and therefore shows one of the smallest payments.)

Table 31—Intrahousehold payment to women for work in project communal rice fields, wet season 1985

Village	Rice Given to Women by Compound Head for Work in Communal Fields	Number of Observations
	(kilograms/day of work)	
Traditional rice growers		
Dasilameh	1.95	62
Pacharr	0.08	104
Sinchou Abdou	1.30	15
Sukurr	2.58	27
New rice growers		
Njoben	a	...
Sare Samba Sumali	0.24	16
Kussalang	a	...
Sare Bala	a	...
Total mean	1.23	224
(US$/day)	(0.35)	

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

[a] Women from these villages work very little in *maruo* (communal) rice (fewer than 10 cases observed in all three villages).

A payment of 2 kilograms per day is equivalent to a daily wage rate of around D2. This is the same amount as a woman's net returns from cultivating a private field of cotton, which was the least productive of the women's crops, but less than the average returns gained by women from swamp rice (Table 17). The highest in-kind payments to women were recorded in Sukurr and Dasilameh (traditional rice-tilling villages), with much lower rates of payment in the Fula villages and in Njoben (a Wolof village).

Combined with these readjustments in divisions of labor by sex and crop, and the altered sources of private farm income for women, there has been an overall centralization of control over the rice crop by the compound head and an associated increase in his authority. For example, the following responsibilities related to rice were mostly in the hands of women when growing swamp rice before the introduction of the new rice technology and are now mainly the purview of the compound head: demarcating plots (between communal and private portions), controlling activities in the fields, assessing how much rice to sell or store, deciding in whose store to keep the rice, and determining the quantity of rice to be used for cooking each day. Because the new rice is a communal crop, women automatically have a reduced say in its production and disposal.

Inevitably, not all women and men have benefited from the increased male involvement in rice production. In compounds with relatively few upland fields that can be taken over by women, or in those where compound heads do not pay the women for their work in the new rice fields, women have suffered an absolute increase in work and a decline in independent income. In other compounds women are faring much better than in former days. A great variety of gainer-loser patterns is apparent. To assess these patterns completely from the income side by looking at time allocation is difficult. Fungibility between male and female income and time, for instance, is difficult to capture. The following consumption and nutrition analysis sheds additional light on the welfare effects for the various compound members and addresses the intrahousehold issues from a different angle.

6

FOOD AND NONFOOD CONSUMPTION EFFECTS

The findings reported in the previous sections showed that technological change in rice greatly increased rice production and added substantially to household food production. Because of substitution effects, net income effects were less sizable. This chapter addresses the extent to which these increases translate into spending on food and nonfood items, availability of food from own production for consumption, and actual consumption of food (in the form of calories). Particular attention is focused on the seasonal effects on food consumption because the study site is well known for its wet-season deficiencies in food availability, which coincide with the highest energy expenditures during this period of heaviest agricultural workload. The dry-season, pump-irrigated rice was found to reduce fluctuations in seasonal cereal availability.

Spending on Food and Nonfood

What do rural households in The Gambia spend their income on, especially their incremental income, and what role does increased income deriving from new rice technology and commercialization play in this context?

The following expenditure information is aggregated on the basis of *sinkiro*-level food consumption (the common pots) and expenditure information from person-by-person recall surveys in each season. In the case of the individual data, about 800 adults were interviewed concerning the previous week's expenditure on food snacks by themselves and their children and on both short-term and long-term nonfood expenditures.

Fifty-six percent of all expenditures (including the value of own-produced food) is devoted to communal food consumption in the *sinkiro*, 10 percent is spent on snack foods, 17 percent on frequently purchased nonfood items (such as soap and tobacco), and 17 percent on (semi-) durables, such as housing, clothes, and household goods. There is considerable stability in the budget shares for these aggregates over the two seasons. Savings, borrowings, and the seasonal depletion and rebuilding of capital stocks all serve to level out the seasonality of agricultural income flows.

There are significant changes in expenditure levels on certain individual items. For example, health expenses are higher during the disease-prone wet season than during the dry season. Housing expenses are concentrated in the late dry-season months when less field work permits more time to be spent on construction work (the wet season 1985 recall period covers the prerains period of 1985). Clothes are typically purchased after money from the groundnut harvest comes in early in the dry season.

Total expenditures substantially exceed recorded total income but the two are reasonably correlated ($r = 0.64$). While part of the difference is probably due to the common underreporting of income, the particularly large difference in the wet (hungry) season of 1985 is mostly the result of household selling of assets for current expenditures in that season, which was particularly difficult after several years of low rainfall.

The share of food expenditures fluctuates more in upland villages between seasons than it does in lowland villages, because the latter have access to more pump-irrigated rice (a second crop) with its leveling effects on seasonality (Table 32). The larger fluctuation in the food budget of upland villages is paralleled by larger absolute seasonal fluctuations in their nonfood budgets.

Table 32—Budget shares of own-produced and purchased food and nonfood items in upland and lowland village sinkiros, by season, 1985/86

Item	Lowland Villages		Upland Villages	
	Wet Season	Dry Season	Wet Season	Dry Season
Common food				
Dalasi/adult-equivalent person	292	442	312	488
Percent of total expenditures	52.9	54.8	61.4	55.1
	(percent of common food)			
Rice	49.3	43.8	38.1	19.4
Millet, sorghum	1.3	12.9	13.5	34.5
Maize	0.6	0.7	3.5	2.8
Groundnuts	4.2	6.7	10.2	18.0
Sauce ingredients	10.1	10.3	6.5	8.4
Vegetables	7.9	4.8	9.4	3.2
Oil	4.8	4.0	2.9	2.2
Fish	6.0	5.7	3.2	4.3
Meat	4.9	4.5	5.0	4.4
Milk	4.0	1.1	4.2	0.5
Sugar	5.2	4.7	3.1	1.9
Other	2.0	0.9	0.4	0.5
Snack food				
Dalasi/adult-equivalent person	50	85	39	96
Percent of total expenditures	9.0	11.2	6.8	11.2
	(percent of snacks)			
Groundnuts (as snacks)	6.5	13.8	4.8	16.3
Bread	33.8	18.6	38.3	21.2
Beverages	14.4	31.5	12.7	27.9
Fruits	21.9	19.8	7.2	13.8
Sugar	19.8	13.3	32.7	20.2
Other	3.6	3.0	2.9	0.7
Frequently purchased nonfood				
Dalasi/adult-equivalent person	109	135	91	136
Percent of total expenditures	20.0	17.4	16.3	16.0
	(percent of frequently purchased nonfood)			
Washing soap	27.8	32.0	29.8	32.0
Energy	17.6	16.9	16.9	16.2
Batteries	10.0	9.3	14.1	17.3
Tobacco, cola nuts	36.9	29.6	34.1	30.9
Transport (short distance)	6.0	8.5	3.9	3.4
Semidurables				
Dalasi/adult-equivalent person	104	131	85	159
Percent of total expenditures	18.2	16.7	15.5	17.7
	(percent of semidurables)			
Housing	4.4	2.7	5.2	2.5
Household goods	19.3	18.4	17.5	15.9
Clothes	31.1	38.6	30.0	39.8
Luxuries	7.7	9.3	10.1	7.9
Health	6.6	4.9	5.9	2.8
Education	2.0	2.4	0.7	0.1
Travel (long distance)	4.1	3.9	4.2	2.7
Festivities	4.8	5.3	6.8	4.8
Bride price	4.0	2.[illegible]	3.8	5.6
Miscellaneous	9.4	5.5	7.2	9.3
Taxes	5.8	6.6	8.6	8.7
Total expenditures (dalasi/adult-equivalent person)	555	793	527	879

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Notes: A *sinkiro* is a cooking and consumption group within a compound. Parts may not add to totals because figures represent the means of share means.

The nonagricultural rural economy benefits from increased income earned from rice production and spent on locally produced goods and services. Table 33 gives a breakdown of average expenditures for the lowest and highest expenditure quartiles. On the basis of this information, it can be calculated that an increase in total expenditure of 10 percent causes expenditures on (semi-) durables to rise by 14.5 percent and expenditures on housing and household goods to rise by 24 percent. Changes in nonfood expenditures, however, start from a very low base. Thus, despite substantial relative changes, the multiplier effects of this increased spending for nonagricultural employment may remain small for the time being. Nevertheless, the potential for nonagricultural growth stimulated through the agricultural growth at the study site is substantial. An increasing diversification of the local economy is observed in the central market village of Brikama Ba (next to Dasilameh), where tailors, goldsmiths and silversmiths, furniture and pot makers, weavers, and car mechanics have converged in the past few years to profit by the increased rice trade.

The tendency to spend incremental income on food is high in this area. This is looked into with a simple regression model, explaining food expenditure levels. The model is formulated with the following hypotheses in mind: a *sinkiro*-size variable (HHSIZE) supposedly controls for scale effects. The variable "income earned from cultivation in new rice project over total income earned in both seasons by *sinkiro* (PROJINC)" tests for effects of new technology in rice production on spending for food beyond its income effect, which is controlled for with the total expenditure variable as an income proxy (lnTOTEX). It is expected that the propensity to spend on food decreases with rising income (lnTOTEXSQ). It should be noted that the value of own-produced food consumed by the *sinkiro* (priced at respective purchase prices) is included in the food expenditures.

$$FOODEX_i = f(HHSIZE_i, \ln TOTEX_i, \ln TOTEXSQ_i, PROJINC_i), \qquad (15)$$

where

$FOODEX_i$ = expenditure on food (including value of own produced) per adult-equivalent person in wet and dry seasons in *sinkiro* (i),

$HHSIZE_i$ = number of adult-equivalent persons in *sinkiro*,

$\ln TOTEX_i$ = total expenditure (log) in both seasons in *sinkiro* per adult-equivalent person,

$\ln TOTEXSQ_i$ = $\ln TOTEX_i$ squared, and

$PROJINC_i$ = income earned from cultivation in new rice project over total income earned in both seasons by *sinkiro*.

The estimation results are presented in Table 34.

It is found that an increase in income from the project does not significantly alter spending behavior toward food beyond its income effect. The parameter value for the variable PROJINC is statistically insignificant. Larger *sinkiros* spend less per capita for any additional member. This may be so because acquisition and preparation of food in bulk in the larger *sinkiros* permits savings.

Applying the parameters to sample mean values suggests that a 10 percent increase in total expenditure leads to a 9 percent increase in food expenditure or, in other words, of an incremental D1.00, D0.60 is spent on food.

Table 33—Budget shares of own-produced and purchased food and nonfood items in sinkiros, by expenditure quartile and season, 1985/86

Item	Lowest Expenditure Quartile		Highest Expenditure Quartile	
	Wet Season	Dry Season	Wet Season	Dry Season
Common food				
Dalasi/adult-equivalent person	196	313	432	711
Percent of total expenditures	59.2	58.8	53.5	54.9
	(percent of common food)			
Rice	48.8	33.2	36.3	35.1
Millet, sorghum	7.7	26.8	9.2	15.2
Maize	1.9	1.4	1.0	1.8
Groundnuts	5.6	12.0	7.1	10.3
Sauce ingredients	8.2	8.0	9.4	9.9
Vegetables	9.2	3.9	8.0	4.8
Oil	2.3	1.7	5.0	4.4
Fish	4.5	5.2	5.5	5.7
Meat	3.6	3.4	7.3	5.8
Milk	2.6	0.9	4.9	1.1
Sugar	4.5	3.2	4.4	4.8
Other	1.2	0.4	2.0	1.3
Snack food				
Dalasi/adult-equivalent person	27	49	72	133
Percent of total expenditures	8.1	9.7	8.7	11.3
	(percent of snacks)			
Groundnuts (as snacks)	5.6	15.9	6.5	13.3
Bread	37.1	22.3	35.6	20.4
Beverages	12.2	25.9	17.6	30.2
Fruits	15.1	20.5	14.1	15.8
Sugar	24.7	13.2	23.6	17.2
Other	3.3	2.1	2.6	3.0
Frequently purchased nonfood				
Dalasi/adult-equivalent person	60	82	143	200
Percent of total expenditures	17.8	15.9	17.7	15.9
	(percent of frequently purchased nonfood)			
Washing soap	27.7	33.5	32.1	29.3
Energy	16.8	16.6	17.6	16.2
Batteries	11.6	10.3	11.8	13.9
Tobacco, cola nuts	40.0	32.7	33.6	31.3
Transport (short distance)	3.6	4.4	3.7	6.0
Semidurables				
Dalasi/adult-equivalent person	49	79	166	230
Percent of total expenditures	14.9	15.5	20.1	17.9
	(percent of semidurables)			
Housing	4.0	1.7	6.8	2.5
Household goods	16.4	18.7	20.0	17.2
Clothes	32.2	42.6	28.9	33.5
Luxuries	7.3	6.5	10.3	12.0
Health	6.5	3.8	5.9	5.0
Education	2.2	1.7	1.3	1.2
Travel (long distance)	3.0	2.8	5.0	3.4
Festivities	6.1	3.6	5.4	4.5
Bride price	2.8	1.3	4.1	5.9
Miscellaneous	8.0	7.3	7.6	7.0
Taxes	9.7	10.2	4.6	7.2
Total expenditures (dalasi/adult-equivalent person)	331	523	813	1,273

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Notes: A *sinkiro* is a cooking and consumption group within a compound. Parts may not equal totals because figures represent the means of share means.

Table 34—Spending on food: regression model

Explanatory Variable	Parameter	t-Value
HHSIZE	−12.64	−6.11
PROJINC	−53.33	−1.19
lnTOTEX	−8,096.71	−9.83
(lnTOTEXSQ)	615.28	11.00
Constant	27,378.81	9.03
$\bar{R}^2$	0.835	
F-value	255.9	
Degrees of freedom	202	

Notes: Dependent variable—expenditure on food in *sinkiro* during wet and dry seasons per adult-equivalent person. A *sinkiro* is a cooking and consumption group within a compound.

The high level of food expenditure elasticities confirms findings from other African surveys reported by Alderman (1986, 38): low-income rural households in two regions of Nigeria show elasticities of 0.89-1.04, and in Sudan, 0.84.

As reported in the next section, calorie consumption increases with rising income, but decreasingly so at the margin opposite to the total food expenditures. Thus it is less a quantity effect than a quality effect in foods consumed that pushes food expenditures relatively upwards. As shown in Table 33, the budget shares of expensive food items such as oils, fish, meat, milk, and snack foods increase disproportionately with higher total expenditures, and more so than the relative reduction in spending on basic foods.

Clearly, demand for food remains high across all income groups. The absolute value of per capita cereal consumption in the top expenditure quartile is 75 percent higher than in the bottom quartile. It can be safely assumed that any income-generating activity in this area will stimulate a rapid expansion in food demand. This has implications for the rapid expansion of food production in rice projects such as the Jahally-Pacharr. It should not come as a surprise that increased food production, adding to income and thus to demand for food (including staples), does not add much to marketed surplus at current consumption levels. Effects of increased income for consumption and nutrition should be expected to be significant under these circumstances.

Calorie Consumption and Sources of Food Energy

In 1978-81, FAO food balance sheets calculated the average daily per capita supply of energy in The Gambia to be 2,251 calories and of protein to be 57 grams (FAO 1985b). (The energy estimate was 4.1 percent less than that made a decade earlier.) Food balance sheets, which provide an estimate of food available for The Gambia as a whole, are based on production, trade, and stock figures, which may not be easy to calculate precisely. Moreover, they do not provide information on geographical, socioeconomic, or seasonal variations in food availability, which may be of considerable nutritional importance. Such information is obtained from household (or individual) food consumption surveys, of which there have been comparatively few in The Gambia.

In 1946, in a small but classic study, Doughty (1950) examined food consumption in five *sinkiros* in Yoro Beri Kunda, a village in our survey area. The annual average figures reported for individual compounds range between 2,365 and 1,556 calories per capita per day in this small but carefully conducted survey. Monthly figures range between 1,240 in the hungry season and 2,780 in the postharvest season.

In 1978/79, in a survey in Lower River Division (about 100 kilometers west of our survey area), Phillips, Coles, and Seaman (1982) studied two lowland villages and found that, on average, seasonal variations in energy consumption were comparatively small. For one village, average per capita calorie intakes were 1,920 in the dry season (March), 1,848 in the wet season (July-September), and 2,147 postharvest (December). For the other village, the figures were 2,110, 2,186, and 2,262 calories, respectively. However, substantial differences were identified in calorie consumption between households. In the dry season, per capita calorie intakes ranged from 1,445 to 2,499 in the 20 main sample households. In the rainy season, the variation between households was from 1,355 to 2,811 calories (Phillips, Coles, and Seaman 1982, 104-105). The surveys of Doughty (1950) and Phillips, Coles, and Seaman (1982) were based on several consecutive records for each time period. The weighed method was used for household food consumption, with individual recall for snacks. Phillips, Coles, and Seaman found that protein intake was above recommended requirement levels throughout the year, mainly because of high groundnut consumption. Since the area of the present study is probably similar in that respect, the following analysis concentrates on calorie consumption and not on protein.

Survey Technique

The reported calorie consumption data below are based on *sinkiro*-level information collected for one week in the rainy season (August-September 1985) and one week in the dry season (February-March 1986). All locally available foods, whether produced by the household or acquired otherwise, are included. Considerable care was taken to also collect information at the individual level on consumption of snack foods, especially the energy-dense ones, such as sweet bread, roasted groundnuts, and sugar. Mothers responded for their children on snack consumption. The *sinkiro*-level information was obtained from the head cooks who were preparing food during the week in question. The recall of food prepared by type and quantity (in local volume measures) worked backwards meal-by-meal and day-by-day.

The number of persons present at meals fluctuates to some extent. Compound members may eat with other *sinkiros*, or omit a meal when shopping at the market, and so on. An effort was therefore made to establish the precise number of persons (adults and children) present at each meal, including visitors.

Certain comments may be made about the methodology. First, in this society, head cooks have little difficulty recalling food prepared, since this is their special function in the *sinkiro*'s daily activities. In more complex situations involving several cooks, several interviews were done for the recall period for the respective days of the week.

Second, the range of foodstuffs available (and particularly those used in quantities to properly affect calorie consumption) was rather small. The measurement made was of food as prepared and served in the *sinkiro*. Since communal dishes were used, individual food consumption could not be obtained. No deduction was made for leftovers, some of which may have been wasted rather than subsequently consumed. Although Phillips, Coles, and Seaman (1982) found this wastage to be very small overall, failure to take account of it will tend to result in slight overestimation of calories consumed (particularly, perhaps in the richest households).

Chronic and Seasonal Hunger

Average per capita calorie consumption in the *sinkiros* was 2,159 in the wet season and 2,269 in the dry season. To this is to be added the consumption of snack foods consumed between meals. These snacks add up to another 221 calories (9.3 percent of total calorie consumption) in the wet season and 253 calories (10 percent) in the dry season.

Table 35 presents the calorie consumption data by expenditure quartiles. This clearly shows the strong positive relationship between income—using total expenditure as a proxy—and calorie consumption. As expected, the relationship is much stronger in the food-scarce wet season than in the dry season (after harvest). Calorie consumption increases by 54 percent from the lowest to the highest quartile in the wet season, but by only 37 percent in the dry season. While in the top quartile, calorie consumption is almost stable over the seasons (+2 percent from wet to dry season), it increased by 15 percent in the bottom quartile. Thus, food consumption by the poor reflects seasonal food scarcity, while the richer *sinkiros* are able to maintain a more constant food intake at a higher level.

Of particular concern are levels and changes of food poverty, that is, deficiencies in food calories in relation to needs. A strong inverse relationship is found between income level and prevalence of calorie deficiency (Table 36). For this particular computation, a requirement level of 2,700 calories per adult-equivalent person was chosen.[27] The prevalence of deficiency is presented for *sinkiros* that fall below 80 percent and below 60 percent of that level. In the hungry season, 18.4 percent are found below 80 percent and 4.2 percent are below 60 percent. By far the largest share of these *sinkiros* are in the lowest income group. Of the other *sinkiro* groups, in both seasons, only a negligible share falls below the 60 percent threshold, some of which may be "reporting noise" in the data. In the study by Phillips, Coles, and Seaman (1982), 30 percent of the 20 sample *sinkiros* had intakes below 80 percent of requirements in the wet season, compared with 10 percent in the dry season (although none were below 60 percent). The relatively higher proportion of *sinkiros* with intakes below 80 percent of requirements (as calculated according to FAO/WHO recommendations) may reflect a situation common for areas without pump-irrigated rice.

A comparable breakdown is given for *sinkiros* with different levels of access to rice fields in the project (Table 37). While deficiencies appear highest in the *sinkiros* that do not participate in the project at all, the picture remains mixed for the others. In the wet season, when project participants are benefiting from the harvest of the pump-

Table 35—Calorie consumption per capita, by income quartile, wet season 1985 and dry season 1986

Income Quartile[a]	Wet Season 1985			Dry Season 1986		
	Sinkiro Food[b]	Snacks	Total	Sinkiro Food[b]	Snacks	Total
			(calories/capita/day)			
Lowest	1,724	169	1,893	2,006	170	2,176
Second	2,009	213	2,222	1,981	245	2,226
Third	2,402	220	2,622	2,526	285	2,811
Highest	2,616	301	2,917	2,648	324	2,972
Total average	2,159	221	2,380	2,269	253	2,522

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

[a] Expenditure is used as a proxy for income.

[b] A *sinkiro* is a cooking and consumption group within a compound.

[27] Any calculation of energy requirement involves an element of judgment. Consideration has been given to recent work on women's energy expenditures and the energy cost of pregnancy and lactation by the Medical Research Center (MRC) unit in The Gambia (see Lawrence et al. 1989).

Table 36—Prevalence of calorie consumption below recommended requirement levels, by income quartile and season, 1985/86

Income Quartile[a]	Below 80 Percent of Requirements: Wet Season	Below 80 Percent of Requirements: Dry Season	Below 60 Percent of Requirements: Wet Season	Below 60 Percent of Requirements: Dry Season
	(percent of *sinkiros*)[b]			
Lowest	49.1	21.2	15.1	3.9
Second	17.3	18.5	0.0	5.6
Third	5.6	5.7	0.0	1.9
Highest	1.9	0.2	0.0	0.0
Total average	18.4	13.7	4.2	3.3

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.
[a] Expenditure is used as a proxy for income.
[b] A *sinkiro* is a cooking and consumption group within a compound.

irrigated dry season crop, increased access to project land is equated with reduced prevalence of calorie consumption deficiencies except in the lowest quartile (which includes a large share of high-income upland farm units). In the dry season, however, the picture is reversed. A considerable portion of those *sinkiros* farming large areas of project land do not consume sufficient calories (17 percent in the top quartile). This must be assessed more rigorously in a multivariate analysis that controls for other factors. Thus this simple tabulation must not be interpreted in a cause-effect perspective. Nevertheless, there are participants who experience calorie-intake deficiencies despite substantial access to the project. These are poor rice farmers with few other income sources.

The most important calorie source in the area is rice. Over both seasons, an average of 55 percent of calories comes from rice, compared with 65 percent in the wet season and 46 percent in the dry season (Tables 38, 39, and 40). While annual averages of that share show little change across income groups, poorer *sinkiros* tend to consume

Table 37—Prevalence of calorie consumption below recommended requirement levels, by access to project rice fields and season, 1985/86

Access to Rice Fields[a]	Below 80 Percent of Requirements: Wet Season	Below 80 Percent of Requirements: Dry Season	Below 60 Percent of Requirements: Wet Season	Below 60 Percent of Requirements: Dry Season
	(percent of *sinkiros*)[b]			
No land in project	20.7	27.6	6.9	13.8
Lowest quartile	17.0	8.7	6.4	0.0
Second quartile	22.2	8.9	0.0	0.0
Third quartile	17.8	11.4	6.7	2.3
Highest quartile	15.2	17.0	2.2	4.3
Total average	18.4	13.7	4.2	3.3

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.
[a] Project land in pump-irrigated equivalent per adult.
[b] A *sinkiro* is a cooking and consumption group within a compound.

Table 38—Sources of calories consumed in sinkiros, by expenditure quartile, wet and dry seasons, 1985/86

Source of Calories	Per Capita Expenditure Quartile of Sinkiros[a] Lowest	Second	Third	Highest	Total Average
	(percent of total calories consumed)[b]				
Rice	53.0	60.2	52.1	54.2	54.8
Millet, sorghum	22.4	13.8	16.4	13.7	16.6
Maize	2.1	1.4	2.8	1.8	2.0
Total cereals	77.5	75.4	71.3	69.7	73.4
Groundnuts	10.7	8.9	11.9	10.8	10.6
Sauce ingredients	0.8	0.8	0.8	0.9	0.8
Vegetables	0.9	0.9	0.8	0.9	0.9
Oil	1.6	2.7	4.0	4.6	3.2
Fish	2.5	2.9	2.5	3.1	2.8
Meat	1.3	1.9	2.2	2.8	2.1
Milk	1.2	1.8	1.6	1.6	1.5
Sugar	3.3	4.5	4.4	5.0	4.3
Other	0.2	0.2	0.5	0.7	0.4
(Average calories/day/adult-equivalent person)	(2,117)	(2,355)	(2,846)	(2,952)	(2,570)

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

[a] A *sinkiro* is a cooking and consumption group within a compound.

[b] Annual averages for wet and dry seasons, 1985/86.

Table 39—Sources of calories consumed in sinkiros, by expenditure quartile, wet season 1985

Source of Calories	Per Capita Expenditure Quartile of Sinkiros[a] Lowest	Second	Third	Highest	Total Average
	(percent of total calories consumed)				
Rice	68.6	70.1	63.2	59.1	65.2
Millet, sorghum	8.7	3.7	6.1	8.5	6.8
Maize	2.4	0.8	3.5	1.3	2.1
Total cereals	79.7	74.6	72.8	68.9	74.1
Groundnuts	6.4	6.8	7.8	8.7	7.4
Sauce ingredients	1.0	0.8	0.8	1.1	0.9
Vegetables	1.5	1.2	1.1	1.0	1.2
Oil	1.6	3.2	4.2	4.9	3.5
Fish	2.4	3.1	2.6	3.1	2.8
Meat	0.9	2.2	2.4	3.2	2.2
Milk	2.0	2.6	2.6	2.5	2.4
Sugar	4.4	5.5	5.2	5.8	5.2
Other	0.1	0.1	0.7	0.9	0.5
(Average calories/day/adult-equivalent person)	(1,973)	(2,324)	(2,741)	(2,860)	(2,477)

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

[a] A *sinkiro* is a cooking and consumption group within a compound.

Table 40—Sources of calories consumed in sinkiros, by expenditure quartile, dry season 1986

Source of Calories	Per Capita Expenditure Quartile of Sinkiros[a] Lowest	Second	Third	Highest	Total Average
	(percent of total calories consumed)				
Rice	40.3	52.2	42.3	49.7	46.2
Millet, sorghum	33.0	22.9	26.5	18.7	25.2
Maize	1.9	1.9	1.8	2.6	2.1
Total cereals	75.2	77.0	70.6	71.0	73.5
Groundnuts	14.3	10.6	15.2	12.7	13.2
Sauce ingredients	0.8	0.8	0.8	0.8	0.8
Vegetables	0.6	0.7	0.7	0.7	0.7
Oil	1.7	2.3	3.6	3.8	2.9
Fish	2.6	2.8	2.5	3.1	2.8
Meat	1.6	1.3	1.9	2.3	1.8
Milk	0.6	0.7	0.7	0.7	0.7
Sugar	2.6	3.6	3.6	4.3	3.5
Other	0.2	0.2	0.3	0.5	0.3
(Average calories/ day/adult-equivalent person)	(2,261)	(2,387)	(2,952)	(3,045)	(2,663)

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

[a] A *sinkiro* is a cooking and consumption group within a compound.

a higher share of their calories in the form of rice in the wet season. In the dry season, the picture is more diverse, but rice in this area is certainly not a rich people's grain. Millet and sorghum consumption is down to a share of 7 percent of calories in the wet season, but accounts for 25 percent in the dry season. Groundnuts emerge as a major food crop, providing an even higher share of calories than millet and sorghum in the wet season (7.4 percent) and 13.2 percent in the dry season. In the wet season, groundnut consumption shows a positive relation to income, but this is not the case in the dry season. All other foods (apart from cereals and groundnuts) provide 16 percent of calories consumed in the *sinkiros*. Sugar and oil dominate among these sources.

Substitution between Rice and Coarse Grains

The sample averages are biased toward rice growers because of the location in which the survey was carried out and the survey's task of assessing the effects of technological change and commercialization of rice production. A designation of villages by location in Table 41 provides information that is more generalizable for The Gambia. The villages outside the project area are lowland villages not affected by the project, and the upland villages were little affected by it. Still, rice is the main calorie source in all these groups of villages, especially in the wet season. In the dry season, upland village groups consume 42 percent of their calories from millet and sorghum before moving to purchased rice when their millet stocks are exhausted (Table 42). In none of the villages does rice provide less than 44 percent of all calories in the wet season, while village averages range between 16 and 67 percent in the dry season. These findings on food consumption patterns suggest for food policy that a focus on rice may be quite sensible, as rice is of vital importance in the diet, especially for the poorest segments of the rural Gambian population. Differences in these cereal consumption patterns by household appear to be largely driven by local and household-level availability. Households readily substitute between the two major types of cereals—rice and millet/

Table 41—Sources of calories consumed in households in project and nonproject villages, by season, 1985/86

Source	Wet Season 1985			Dry Season 1986		
	Lowland Villages	Upland Villages	Villages Outside Project (Lowland)	Lowland Villages	Upland Villages	Villages Outside Project (Lowland)
	(percent of total calories consumed)					
Rice	71.6	53.0	71.2	58.8	25.3	46.7
Millet, sorghum	1.7	15.9	4.1	15.5	42.1	22.5
Maize	0.8	4.6	0.4	0.8	3.2	4.8
Total cereals	74.1	73.5	75.7	75.1	70.6	74.0
Groundnuts	5.0	12.5	4.0	9.5	19.8	11.3
Sauce ingredients	0.9	0.9	1.1	0.8	0.8	0.8
Vegetables	1.2	1.3	1.0	0.7	0.5	1.2
Oil	4.4	2.4	2.5	3.7	1.9	1.7
Fish	3.3	1.9	2.9	3.2	2.5	1.6
Meat	2.2	1.6	3.7	1.6	1.7	3.2
Milk	2.5	2.4	2.0	0.7	0.3	1.5
Sugar	6.0	3.5	6.8	4.4	1.8	4.5
Other	0.6	0.2	0.3	0.4	0.2	0.3
(Average calories/day/adult-equivalent person)	(2,386.0)	(2,656.0)	(2,390.0)	(2,589.3)	(2,900.7)	(2,321.6)

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.
Note: Parts may not add to totals because of rounding.

sorghum—within the year. This is visible at the village level, too. Millet and sorghum are the dominant sources of calories in the dry season in four of the eight participant villages. In these villages seasonal consumption switches between coarse grains and rice. In Sinchou Abdou, for instance, the rice share of calories moves between 67 percent and 27 percent in the wet and dry seasons, respectively, and in Sare Samba Sumali, between 78 percent and 25 percent. The villages that grow more rice also mainly eat rice year-round. Pacharr, Dasilameh, and Sukurr are such cases, with low shares of millet and sorghum consumption—from 0.1 percent to 11.0 percent between seasons. These villages have the highest access to project rice land by virtue of their status as traditional rice growers.

Consumption patterns throughout a season seem to be driven by availability, which is in turn determined by labor productivity in alternative grains. Enhanced supply of upland cereals, possibly as a result of yield-increasing technology, would face minimal demand constraints according to current consumption behavior. Replacing rice, especially in the dry season, appears to be fairly straightforward in this rural setting. However, the substitution of coarse grains for rice may be lower in urban areas of West Africa (Reardon, Delgado, and Thiombiano 1987). Price ratios and the time involved in food preparation (pounding millet takes considerably longer than pounding rice) do, of course, also affect the demand for millet and sorghum in rural areas, but mainly in the wet season when cash is less available and women's time more scarce.

If labor productivity in rice is increased by the rice project, consumption will shift more toward rice in households that have access to the new technology. Local trade does not level out the differences in availability by type of cereal crop over the seasons. To a large extent, one eats what one has grown. Limited trade of cereal-for-cereal takes place. There appears to be little desire to have a more frequent change in the cereal diet. When the millet-growing compounds have nearly exhausted their millet stock,

Table 42—Major sources of calories, by village and season, 1985/86

Village	Wet Season 1985				Dry Season 1986			
	Total Calories/ Adult-Equivalent Person/Day	Rice	Millet, Sorghum	Ground-nuts	Total Calories/ Adult-Equivalent Person/Day	Rice	Millet, Sorghum	Ground-nuts
		(percent of total calories)				(percent of total calories)		
Lowland villages in project								
Pacharr	2,372	75.6	0.1	5.0	2,748	65.5	11.1	8.2
Dasilameh	2,346	65.4	1.3	4.5	2,230	66.6	5.1	6.8
Sinchou Abdou	2,537	67.3	10.7	7.3	2,352	27.3	46.5	19.6
Sare Samba Sumali	2,450	78.2	1.1	4.1	3,404	25.3	47.0	16.7
Upland villages in project								
Njoben	2,603	44.1	20.8	15.8	2,719	16.1	56.1	19.3
Kussalang	2,875	65.9	16.8	4.0	3,492	24.2	35.4	21.8
Sukurr	3,176	59.5	3.6	16.5	2,811	46.5	1.8	20.2
Sare Bala	1,904	75.6	0.0	2.2	3,032	54.7	22.4	18.3
Villages outside project area								
Teneng Fara	2,608	66.9	6.3	4.4	2,579	38.7	28.8	11.1
Touba N'ding	2,134	75.8	1.6	3.6	2,018	56.0	15.1	11.5

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

they enter the market in the wet season, which implies the purchase of rice—identified in Chapter 5 as the primary traded cereal.

Effects on Calorie Consumption

A better understanding of the complex chain of links from technological change with commercialization through income to consumption can provide guidance on policy and programs for improved nutrition through agricultural development. The following analysis of the determinants of calorie consumption sheds further light on this.

A calorie-consumption model is specified and estimated separately for each of the two main seasons—wet (1985) and dry (1986). The dependent variable is the total calorie consumption per adult-equivalent person in each *sinkiro* (CALAE), which consists of the common *sinkiro* food and the snack food (derived from the recall surveys). Conventional demand theory leads to the hypothesis that calorie consumption is determined by income level (INCOME)—with a decreasing effect as income rises (INCOMESQ)—and market price of the major traded staple (RICEPR). Only the rice price, not other grain prices, is included in the model, because of the dominating role of rice and correlation with prices of other calorie-rich foods.

In the context of the marketed surplus model (Chapter 5), the problem of prices being potentially endogenous to type and scale of transaction and household income was alluded to. In the marketed surplus model, village mean prices were used because of variation of prices over the season. Seasonality is eliminated in this consumption model, as it is based on information covering one week in each season and the models are run separately for the two seasons. Intravillage price variation is larger than intervillage variation. An attempt was made to explain this price variability by household income, size of purchased quantity (scale effects), and distance to markets, which did not result in significant parameters for any of these variables. If there were endogenous relationships, a two-stage least square simultaneous estimation of price and quantity relationship would be called for. The observed price variability between households in the same village at the same time is due to factors such as discount transactions between relatives and friends inside or outside the village and acquisition of rice at different prices by household members traveling in the area or even to one of the distant cities. The actual price paid by the households was thus used in this calorie consumption model.

From larger *sinkiro* populations, positive scale effects due to less waste (SIZE) are expected in organizing food consumption, for instance. It is hypothesized that a higher share of cereals produced under women's control (WOMCER) has a positive consumption effect beyond the income effect of cereal production. This hypothesis is suggested by anecdotal indications that women's preference for spending income that they control on basic food is higher than men's. It would imply that women's *relative* loss of access to rice land leads to less-than-expected positive income effects of the new rice on consumption.

Somewhat related to this hypothesis, a test was conducted if an increased share of income in the form of cash (CASHIN) reduces the consumption of calories when income level is controlled for. This hypothesis is based on the notion that cash may end up in nonfood expenditure or purchased luxury foods to a larger extent than does subsistence food income. This may come about because of transaction costs and a different attitude of household members toward spending cash versus in-kind (food) income. It should be noted that much of the cash income is from groundnuts and comes in a lump sum.

It was further hypothesized that available food in storage (STORAGE), in the context of expected and current income, determines offtake and thus calorie consumption, especially in the wet season. Storage levels relate very little to income, as described in Chapter 5 (Table 27). Wet-season storage levels are largely determined by access to fully water-controlled rice in the project (apart from some large millet farmers).

Due to the apparent local differences in consumption, a variable was introduced that separates the lowland from the upland villages (LOCATION).

The per capita consumption information that forms the dependent variable involves knowing how many people attended *sinkiro* meals. As described above, the number of adults and weaned children eating each meal was recorded. When calculating "adult equivalents," a child was counted as 0.762 of an adult (men = 1, women = 1). Thus, for the calories-per-adult-equivalent variable—other than for the demographic structure of the compound personnel aggregated into adult equivalents used elsewhere in this analysis—a simpler weighting of persons had to be applied. The adult equivalents so formed are somewhat crude, but as many *sinkiros* were large, more detailed records of the age and sex of persons attending each meal was impracticable. To correct for further differences in demographic composition, (j) variables representing the population of the *sinkiros* (DEMOGR) were included at the beginning of each survey round. This allows accounting for variations both in the total size and in the precise age and sex composition of individual *sinkiros*. The analytical approach chosen here has the advantage that it is left up to the estimation procedure to determine differences from norm data whose applicability to the location remains questionable.[28] The stated hypotheses lead to the following model specification with each *sinkiro* (i):

$$CALAE_i = f(INCOME_i, INCOMESQ_i, RICEPR_i, STORAGE_i, WOMCER_i, CASHIN_i, LOCATION_i, DEMOGR_{ij}). \quad (16)$$

The model results are presented in Table 43. The following findings can be highlighted:

1. Calorie consumption is significantly income elastic, but with increased income the increase in calorie consumption is reduced, as indicated by the negative parameter estimated for the squared income term. The role of income for calorie consumption is more pronounced in the hungry season. A 10.0 percent increase in total annual income—at sample means—leads to a 4.8 percent increase in wet-season calorie consumption, but to only a 3.7 percent increase in calorie consumption in the dry season, when most households are well supplied with food.

2. An increased rice price, which stands for an index of cereal price, reduces calorie consumption as expected. In the wet season, a 10.0 percent price increase would reduce calorie consumption by 2.6 percent. The increased supply of rice due to technological change, with its likely price-depressing effect, can therefore be expected to have favorable consumption effects due to the price effect.

3. A reduced share of cereals from women's production reduces calorie consumption significantly in the wet season. Thus the shifting of women's *kamangyango* (private crops) and female-controlled *maruo* (communal crop) to the control of the compound head leads to reduced calorie consumption once income levels are controlled for.

[28] On the basis of a detailed activity survey in the village of Keneba (The Gambia), Roberts et al. (1982, 668-678) found that during the dry season lactating women were active 55 percent of the working day. In the early rainy season, this figure increased to 92 percent. For pregnant women, it was observed that activity increased from 50 to 83 percent in the rainy season.

Table 43—Calorie consumption models for wet and dry seasons

Variable[a]	Wet Season		Dry Season	
	Parameter	t-Value	Parameter	t-Value
INCOME	1.59329	7.218	0.94939	3.341
INCOMESQ	−2.067E−04	−5.316	−4.43508E−05	−0.853
RICEPR	−572.59043	−1.590	−635.95121	−2.030
STORAGE	4.26204	1.702	0.39015	0.464
WOMCER	321.83780	2.088	−57.30427	−0.264
CASHIN	67.74398	0.444	556.30173	1.707
LOCATION	−360.16405	−3.321	−319.89069	−1.994
SIZE	−16.89431	−1.949	−36.76049	−3.374
WOMSH	817.08670	1.823	1,478.36650	3.536
CHLD5SH	624.70833	1.038	553.32630	0.961
CHLD10SH	834.17860	1.812	626.22141	1.277
CHLD14SH	981.11329	1.867	1,364.50750	2.187
Constant	1,616.86638	2.937	2,755.13502	3.612
$\bar{R}^2$	0.37		0.37	
F-value	9.65		9.72	
Degrees of freedom	197		197	

Notes: Dependent variable—calorie consumption per adult-equivalent person per day in respective season. A *sinkiro* is a cooking and consumption group within a compound.

[a] Definitions of variables:

INCOME = total expenditure (as income proxy) per adult-equivalent person for year 1985/86 (in dalasi);
INCOMESQ = income squared;
RICEPR = rice price in dalasi/kilogram actually paid for purchases by household (if no purchase, village mean price of season);
STORAGE = storage of all grains (in rice equivalents) per adult-equivalent person in respective season;
WOMCER = share of cereals produced in *sinkiro* under women's control: 1985 wet-season estimation uses harvest from 1984 wet season and 1985 dry season; 1986 dry-season estimation uses 1985 wet-season harvest;
CASHIN = share of cash income over total income earned by *sinkiro* in respective season;
LOCATION = dummy variable = 1, if lowland village (else = 0);
SIZE = size of *sinkiro* in adult-equivalent persons;
WOMSH = share of women in adult-equivalent persons;
CHLD5SH = share of children under 5 years of age in adult-equivalent persons;
CHLD10SH = share of children 5-10 years of age in adult-equivalent persons; and
CHLD14SH = share of children 10-14 years of age in adult-equivalent persons.

Maintained or expanded control by women of the cereal crop (rice) when production increases with new technology would have a beneficial effect for calorie consumption. If beneficial net effects for calorie consumption are to be achieved, given the changes in crop control, the income growth from technological change in rice must be higher to compensate for this adverse intrahousehold effect. A drop of women's share in cereal production from 30.0 percent (the sample mean) to 10.0 percent (the share in many *sinkiros* with pump-irrigated rice in the project) would, holding income constant, reduce per capita calorie consumption by 64 calories per adult equivalent, or 2.2

percent in the wet season. (The effect is not significant in the dry season when supplies are high.) To compensate for this with a higher income—given the estimated income elasticity of calorie consumption—would require an increase of 4.6 percent in income. This is much less than the income increase of about 13.0 percent estimated earlier that is due to the new technology in lowland villages. The relative diversion of income from calories after women lose control of rice is therefore less than the favorable effect for calorie consumption deriving from a higher total household income. The trade-off exists, however, and although clearly recognized as a net improvement on average, may not always bring this result.

4. An increased share of cash income does not, as hypothesized, reduce calorie consumption once income is controlled for. In the dry-season model, it turns out to be just significantly positive. More cash income in total income increases calorie consumption beyond the income effect (it should be noted that the cash share in total income is not correlated with total income [r = −0.005]). In the wet-season model, no significant effect of cash income beyond total income is found. More cash income does find its way into calories for the *sinkiro,* and these are to some extent in the form of snack foods. Increased monetization of the economy in this West African setting does not appear to be adverse for food consumption.

5. Larger *sinkiros* consume significantly less per adult-equivalent person. In a *sinkiro* with 20 adult equivalents versus one with 10, every adult (equivalent) person uses 5.8 percent fewer calories in the wet season and 11.7 percent fewer in the dry season. One interpretation suggests that these are the favorable effects of economies of scale. However, an alternative interpretation can be that in larger *sinkiros* various subgroups of the family may not obtain as much food as in smaller *sinkiros*. Children may end up more neglected. This hypothesis is tested further in the following nutritional status analysis.

6. The demographic variables show that the variable representing women's share in the number of adult equivalents in the household is positively significant. This is so even though women were weighted equally to men in the adult-equivalent count of meal participants. One likely interpretation of this is that in *sinkiros* with a high proportion of women there is more female labor available for food preparation and more food is, therefore, prepared and subsequently eaten. Another interpretation is that women, with their relatively heavy energy expenditure and easy access to the kitchen, actually do need and eat more than men.

At higher income levels, *sinkiros* spend absolutely and relatively more on expensive food items, such as meat and palm oil (see Table 33). This means that the per calorie cost of the diet rises. The differences between income groups are particularly pronounced in the wet season, when the poor economize on consumption by a switch to a lower-cost diet, a tendency that is less usual among higher-income groups. In the wet season, the lowest quartile spend 31 percent less per calorie than the top quartile as a result of dietary choices, but in the dry season, only 21 percent less (Table 44). Spending per 1,000 calories increased from D0.66 to D0.99 between the two seasons, which partly reflects price inflation (the average rice price went up from D1.33 to D2.05 per kilogram) and partly is the consequence of a change in diet composition. In the poorest quartile the unit cost of calories increased by 66 percent from wet to dry season (which is 8 percent more than the rice price increase). In the top quartile, the per calorie cost increase was 44 percent. Thus it is the lower income groups that bear the main burden of adjustment to (seasonal) price and income fluctuations (see also Table 35).

Table 44—Unit cost of calories, by income quartile and season, 1985/86

Income Quartile[a]	Unit Cost per 1,000 Calories Consumed by Group		Increase from Wet Season to Dry Season
	Wet Season 1985	Dry Season 1986	
	(dalasi)		(percent)
Lowest	0.56	0.93	66.1
Second	0.60	0.91	51.7
Third	0.65	0.94	44.6
Highest	0.81	1.17	44.4
Average	0.66	0.99	50.0

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

[a] Expenditure is used as a proxy for income.

7

NUTRITIONAL EFFECTS

Children in The Gambia are considerably affected by malnutrition. There are complex interactions between seasonality in food production, health environment, mothers' activity patterns, food availability, and household income that affect child nutrition. The chain that leads to high prevalence rates of malnutrition and high mortality rates among children begins with low birth weights and early growth faltering due to an adverse health environment and their mothers' time constraints in the wet season. The low birth weights result from increased stress on pregnant women due to high energy expenditures (at peak of fieldwork) and low intakes in the wet season. Similarly, seasonal energy stress reduces breast milk production, which then reduces weight gains in older babies (Prentice 1980, 167-183). Toddlers and children are affected by the quantity and quality of food available and by the frequency of meals served in the *sinkiros*. For them, household-level calorie availability may be of more direct relevance for nutritional status than the indirect effects of income generation and the nutrition and health status of mothers and caretakers.

Separating the actual effects of unsatisfactory food consumption from health problems (such as infectious diseases and diarrhea) remains difficult. It is probably their dynamic interaction, rather than a clearly separable cause and effect chain, that leads to the worrying nutritional deterioration of many children by the age of two years. The cross-sectional analysis that was performed on the basis of the survey has obvious limitations in capturing the dynamic interactions of health and nutrition.

As Payne (1987, 37) stresses:

> For very young children, a major environmental stress is infectious disease. These not only induce some of the same kinds of physiological adjustments as direct food deprivation; they actually cause undernutrition by reducing appetite. Both together can produce changes in growth control mechanisms which are largely irreversible, resulting in major adjustments in body size of whole populations, the health implications of which are at present little understood, but which are only changeable over periods of generations.

Better understanding of the health-nutrition relationship is crucial for public policy aimed at improving both the household food and health entitlements. To further quote Payne on this issue:

> At the level of the household, resource allocation decisions which take account of the child's need ought, however, to be based on a better understanding of the linkages between those two entitlement sets, and of the pivotal role of women (generally, not only mothers) in those decisions. Combining together the outcome of food deprivation and disease, as if these causes were interchangeable and indistinguishable, will not help in deciding for example whether women's labor time is better deployed in earning cash for more food, or controlling the disease transmission environment in the home, or spending time administering oral rehydration therapy.

Nutrition and Health in The Gambia and the Survey Area

No representative countrywide data on the prevalence of child malnutrition is available for The Gambia. The best alternative is data from growth monitoring by

Catholic Relief Services (CRS) of children participating in CRS nutrition schemes. Data for 1985 suggest that, according to the season, 33-45 percent of the children in the programs were below 80 percent of reference standard weight-for-age (Table 45).[29] As the program makes an attempt to target malnourished children—and does to some extent achieve this (Gambia 1985c)—the figures presented are probably higher than the actual national prevalence of malnutrition. The relative regional distribution of the CRS figures indicates an above-average prevalence in MacCarthy Island Division, which is the area of the IFPRI/PPMU survey.

Methods of Anthropometry Survey

The nutrition data of the IFPRI/PPMU survey are based on weight and height measurements of children under the age of 10 and their mothers. Age was carefully identified for those children who did not have a clinic card or other birth-date record. However, for children older than 6 years who had no record, age recall was sometimes problematic. All children in the survey population were measured once in the wet season (August-September 1985) and once in the dry season (February-March 1986) with the help of length-boards. Weights were taken at the same time. Height measurements were made with stachometers or length-boards (for those less than 24 months of age). Weight measurements were made with hanging scales (for children) or "bathroom" scales (for women). All measurements were made within the household by a

Table 45—Prevalence of malnutrition in The Gambia, by region and season, 1985

Region	Children Aged 0-5 Years Monitored by CRS[a]	Children Below 80 Percent of Weight-for-Age Among Those in CRS Schemes			
		January-March	April-June	July-September	October-December
		(percent)			
Western Division	15.1	25.0	27.0	32.0	37.0
Lower River Division	31.4	34.0	35.0	36.0	44.0
North Bank Division	29.4	34.0	32.0	39.0	47.0
MacCarthy Island Division	10.6	41.0	44.0	48.0	53.0
Upper River Division	12.9	36.0	39.0	36.0	47.0
Country average	14.8	33.0	34.0	38.0	45.0

Source: The data were provided by the Banjul office of Catholic Relief Services in a more disaggregated tabulated form.
[a] CRS = Catholic Relief Services.

[29] Field surveys such as the IFPRI/PPMU survey normally use weight and height (on their own or related to age) to describe anthropometric status. Height-for-age is a long-term measure of a child's nutrition and health experience, since it represents total growth achieved. A "stunted" child is one who is short for his age (that is, one who has grown inadequately). Weight-for-age reflects the total growth history of the child, but since weight can be rapidly lost (or gained), it is also influenced by the child's recent nutrition and health experience. Weight-for-height is usually considered the measurement that best expresses the child's present nutritional situation. The thin or "wasted" child is regarded as showing evidence of recent nutritional deprivation. These anthropometric measurements are compared with those found in a standard "reference" population (where food is freely available and health is good). Malnutrition is said to occur in those individuals whose measurements fall below defined cut-off points when compared with these standards. In the case of weight-for-age, children below 80 percent of standard are commonly classed as at least moderately malnourished (those below 60 percent are classed as severely malnourished).

specially trained and supervised team. Child identification was verified by enumerators familiar with the compounds.

Information on the structure and prevalence of malnutrition in the survey population is presented in this chapter. Thereafter, this information will be related to the technological change in rice production in a descriptive account. Subsequently, in multivariate analyses, an attempt will be made to explain differences in the nutritional status of children in order to identify efficient ways of improving nutrition and to clarify the potential role of agricultural development in this context.

For much of the presentation, the concept of "Z-scores" is used to express the extent to which a child's anthropometric measurements (weight-for-age, height-for-age, weight-for-height) deviate from median or average age-specific measures in a reference population. The Z-score is computed as follows for each child's observation:

$$\frac{\text{Actual child's measure} - \text{reference value}}{\text{Standard deviation of reference population}}$$

A Z-score of zero is "normal," although one must also allow for normal individual variation around that norm. Conventionally, a Z-score value of below minus 2 is considered malnourished. The World Health Organization/National Centre for Health Services standards are used here as references.

Nutritional Status in the Sample Population

The average values of Z-scores of the sample population show that children start on average with a normal weight, but that weight deteriorates rapidly in the 7-to 12-month age group, especially in the wet season (Table 46). This deterioration continues so that children of weaning age (13-24 months) have average Z-scores of −2. In fact, 50.7 percent of them are below −2. In this age group, a considerable degree of stunting prevails (see height-for-age, Table 46), combined with wasting (see weight-

Table 46—Nutritional status of children, by age group as measured by Z-scores, 1985/86

Age Group	Number of Observations: Wet Season	Number of Observations: Dry Season	Mean Values of Z-Scores: Height-for-Age: Dry Season	Weight-for-Age: Wet Season	Weight-for-Age: Dry Season	Weight-for-Height: Wet Season	Weight-for-Height: Dry Season
(months)							
1–6	46	39	0.07	−0.07	0.61	0.10	0.55
7–12	51	39	−1.40	−1.58	−1.19	−1.14	−0.11
13–24	75	80	−1.80	−2.02	−1.52	−1.33	−0.60
25–60	241	201	−1.39	−1.41	−1.33	−0.62	−0.57
61–120	299	284	−0.51	−0.90	−0.72	−0.78	−0.58
Totals							
1–120	712	643	−0.96	−1.17	−0.95	−0.75	−0.47
1–60	413	359	−1.33	−1.37	−1.15	−0.74	−0.41

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

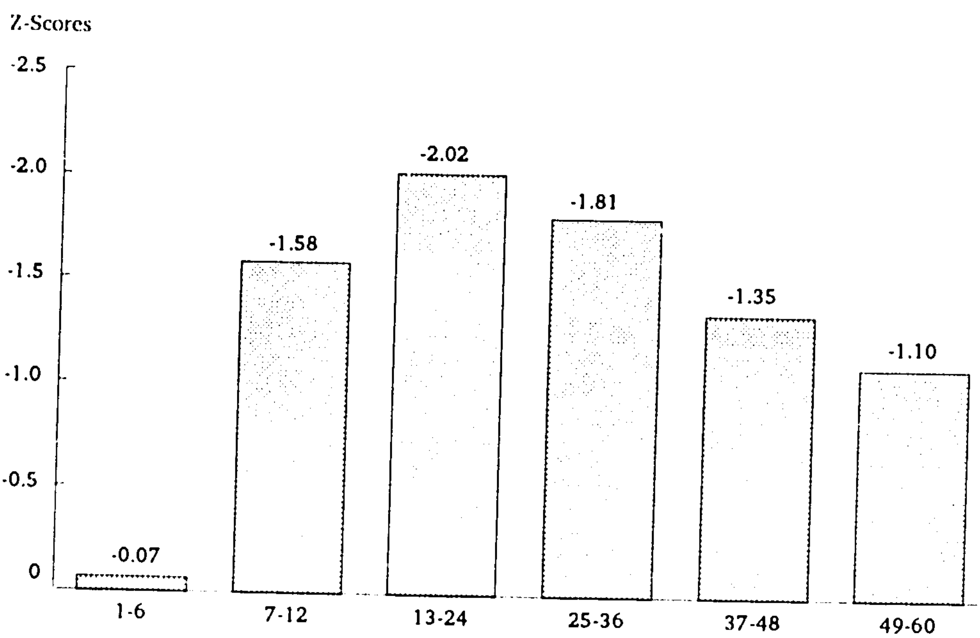
Notes: Wet-season data are for August-September 1985 (preharvest "hungry season"). Dry-season data are for March 1986.

for-height in Table 46). The situation appears to improve as children grow older (Figure 6), but this interpretation of the relative improvement in Z-score values after the age of 13-24 months may be misleading. Children with a particularly high degree of malnutrition are more likely to die at a young age, thus the average Z-score figure for the surviving children may rise. For instance, the average weight-for-age Z-score value of the 10 children (7-30 months of age) who died between the two survey rounds (July/September 1985-March 1986) was −2.98 in the first round, indicating very serious undernutrition, while the general average was −1.86 for this age group.

The percentage of malnourished children is higher in the wet season than in the dry season. In the wet season, 35 percent of the children aged 1-60 months were below 80 percent of the standard weight-for-age (Table 47). Those aged 7-24 months not only had the highest proportion of malnourished children but also showed the greatest seasonal variation. Children who are born late in the dry season or early in the wet season show a much worse nutritional status than children born at other times (Table 48). These "start conditions" of children determine their growth performance throughout their childhood. Significantly fewer children (by 24 percent) born in the "bad" season are among the living children in the sample. This may be partly a result of higher mortality of children born in this season. It may also be partly a result of planned seasonal birth spacing, or simply the result of seasonal patterns of leisure and pleasure. It is clear, however, that seasonality has profound implications for nutritional status. Given the rice project's effect on seasonal food supply and income, a positive effect might also be expected in the realm of nutrition.

In general, nutritional status is better in the dry season than in the wet season. This is especially true where weight-for-height indicators are concerned. However,

Figure 6—Weight-for-age of children aged 1-60 months, wet season 1985



Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Table 47—Prevalence of malnutrition of children, by age group

Age Group	Height-for-Age, Dry Season, Less Than 90 Percent	Weight-for-Age: Wet Season, Less Than 60 Percent	Weight-for-Age: Wet Season, Less Than 80 Percent	Weight-for-Age: Dry Season, Less Than 60 Percent	Weight-for-Age: Dry Season, Less Than 80 Percent	Weight-for-Height: Wet Season, Less Than 80 Percent	Weight-for-Height: Dry Season, Less Than 80 Percent
(months)	(percent of children less than __ percent of median)						
1-6	2.6	...	10.9	...	5.1	...	...
7-12	10.3	2.0	51.0	2.6	28.2	19.6	2.6
13-24	21.3	5.3	52.0	2.5	32.5	7.9	2.5
25-60	16.9	1.2	31.0	0.5	27.3	3.7	1.5
61-120	5.2	1.0	25.7	...	16.3	4.3	1.4
Total 1-120	10.9	1.5	31.1	0.6	21.1	5.3	1.5
1-60	15.6	1.9	35.0	1.1	26.3	6.0	1.7

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

there are differences between villages. For instance, Njoben and Kussalang (two upland villages) show substantially less seasonal fluctuation in children's nutritional indicators than Pacharr or Dasilameh (two lowland villages highly involved in the project [Table 49]). Njoben and Kussalang were identified earlier as comparatively "rich" villages with high levels of food consumption. This may indicate that at high income levels the pronounced seasonal production fluctuations in upland villages are coped with more easily and have a limited effect on children's nutritional status.

This indication is supported by the nutritional data organized by income levels of households in Table 50. Especially the more long-term indicators of nutritional status (height-for-age and weight-for-age) are positively related to income level, and particularly for those aged 5-10 years. Seasonal differences tend to be higher among the poor. Overall, however, the results are hard to interpret in monocausal ways, given the host of factors affecting nutritional status. More refined approaches will therefore be applied to trace the income-consumption-nutrition relationships in regression analyses below.

With more rice land in the new project, the proportion of stunted children (low height-for-age) is smaller (Table 51). As far as weight-for-age is concerned, however, in the wet season greater access to the project's rice land is not associated with improved nutritional status. In both seasons, the highest proportion of children with poor weight-for-height was in the group with no project rice. It is clear that the data in Table 51 cannot be easily interpreted as a cause (project) and effect (nutrition) relationship. More rice land in the project may have various implications for the different factors

Table 48—Nutritional status of children aged 1-60 months, by season of birth

Indicator	Average Z-Score Values: Born During September-February[a]	Average Z-Score Values: Born During March-August[b]
Weight-for-age	-1.46	-1.72
Height-for-age	-1.22	-1.63
(Number of observations)	(204)	(156)

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

[a] Late wet season and early dry season.

[b] Late dry season and early wet season.

Table 49—Nutritional status of children aged 6-59 months, by village and season, 1985/86

Village	Average Weight-for-Height Z-Scores of Children 6–59 Months		Average Weight-for-Age Z-Scores of Children 6–59 Months	
	Wet Season	Dry Season	Wet Season	Dry Season
Lowland villages in project				
Pacharr	-0.99	-0.54	-1.60	-1.39
Dasilameh	-0.84	-0.59	-1.60	-1.34
Sinchou Abdou	-0.75	-0.54	-1.60	-1.35
Sare Samba Sumali	-0.92	-0.46	-1.35	-1.37
Upland villages in project[a]				
Njoben	-0.75	-0.70	-1.51	-1.55
Kussalang	-0.48	-0.46	-1.34	-1.18
Sukurr	-1.38	-0.43	-1.72	-1.22
Villages outside project area (lowland)				
Teneng Fara	-0.73	-0.77	-1.22	-1.19
Touba N'ding	-0.39	-0.23	-1.79	-1.59
Total average	-0.81	-0.57	-1.56	-1.41

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

[a] The village of Sare Bala is not included here because of limited numbers of observations.

that influence nutritional status. Income may rise and food availability may increase, thus a potential for improved nutrition is there. On the other hand, mothers' time may be more constrained and child-care quality may suffer due to work load. Also, small children carried more frequently to the project fields by their mothers may be exposed more to malaria. This project uses ponded water, which in some situations presents a health hazard. The net effect of such factors will be addressed in the model analysis below, which also tests for the statistical significance of the apparent differences diagnosed

Table 50—Prevalence of malnutrition among children, by household income level and season, 1985/86

Indicator	Age Group	Season	Income Quartile[a]				
			Lowest	Second	Third	Highest	Average
	(months)		(percent of children)				
Less than 90 percent							
Height-for-age	6–59	Wet	30.1	13.8	13.1	14.3	17.1
Less than 80 percent							
Weight-for-age	6–59	Wet	40.5	37.9	36.9	39.3	38.5
Weight-for-age	6–59	Dry	28.3	30.1	36.3	20.8	28.8
Weight-for-height	6–59	Wet	9.3	6.0	5.9	7.1	6.9
Weight-for-height	6–59	Dry	5.7	1.0	2.7	0.0	2.0
Less than 90 percent							
Height-for-age	60–120	Wet	11.0	5.6	7.7	3.0	6.9
Less than 80 percent							
Weight-for-age	60–120	Wet	32.8	29.2	24.3	15.2	25.8
Weight-for-age	60–120	Dry	16.7	19.0	20.6	10.5	16.7
Weight-for-height	60–120	Wet	4.1	5.6	2.6	4.6	4.3
Weight-for-height	60–120	Dry	0.0	1.3	2.7	1.3	1.4

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

[a] Total expenditures per capita per year is used as an income proxy.

Table 51—Prevalence of malnutrition among children aged 6-59 months, by access to project land and season, 1985/86

Indicator	Season	Level of Compound Access to Project Land[a]					
		No Project Rice Land	Lowest Quartile	Second Quartile	Third Quartile	Highest Quartile	Average
		(percent of children)					
Less than 90 percent							
Height-for-age	Wet	33.3	17.1	16.9	13.2	14.0	17.1
Less than 80 percent							
Weight-for-age	Wet	30.0	37.7	33.7	43.4	45.6	38.5
Weight-for-age	Dry	17.8	33.2	34.2	26.8	21.4	28.8
Weight-for-height	Wet	12.9	5.7	6.7	7.8	5.3	6.9
Weight-for-height	Dry	3.6	1.2	2.4	1.8	1.8	2.0

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.
[a] Pump-irrigated land equivalent per adult-equivalent person.

in the above tabulations. It is noteworthy that mean values and prevalence rates of nutritional status and malnutrition are not the only changes in association with socioeconomic and health-related variables—the whole distribution pattern also changes, as highlighted in Figure 7. The distribution of weight-for-age Z-scores of the child population from compounds with most access to new rice land is considerably shifted into the ± 1 Z-score area and no longer looks normally distributed.

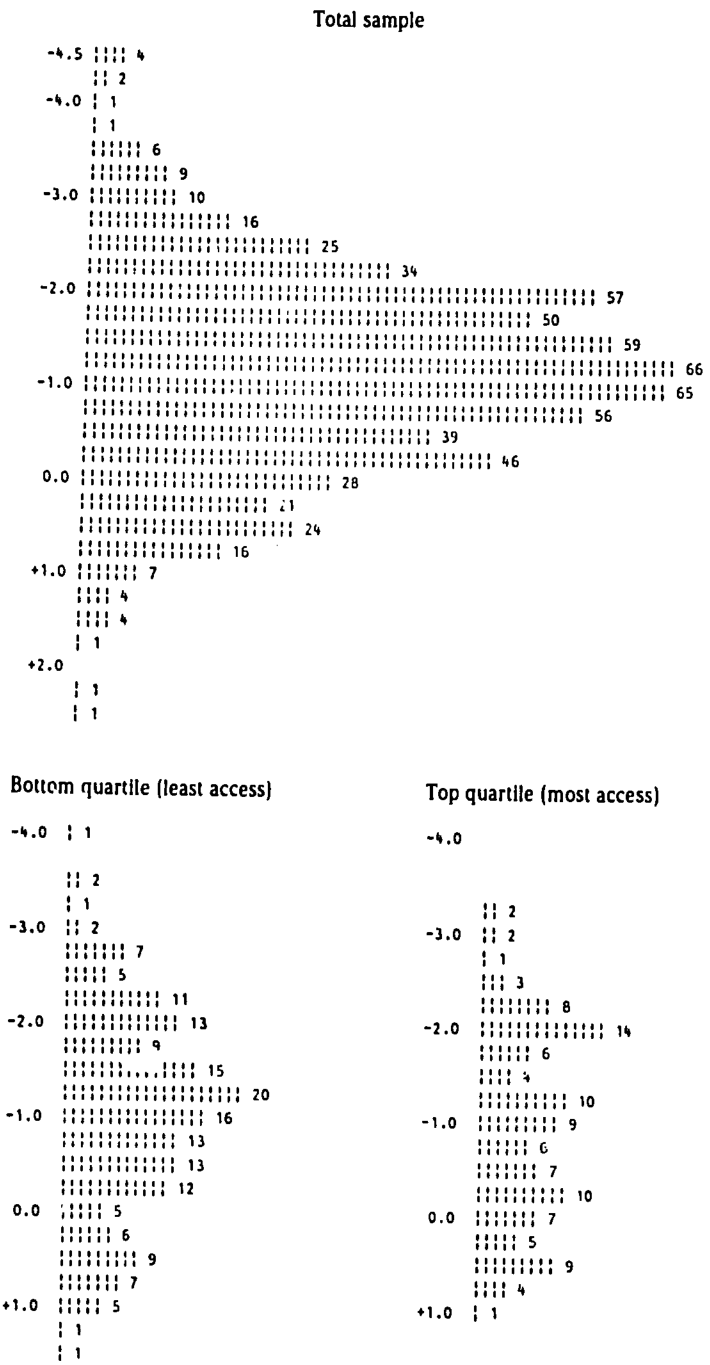
Prevalence of morbidity and mortality does not show a clear association with access to new rice land. Child mortality appears to decrease with access to more rice in the project. Diarrhea prevalence shows no difference between the top and bottom quartiles; fever (malaria), however, appears to increase. It should be noted that the population with most access to the project already lives close to the swamps, which are traditionally malaria-prone.

Mothers' Nutritional Status and Time Allocation

Mothers' health, activity patterns, and time allocation are of greatest importance for children's nutritional performance. To get an indicator of their nutritional status, the weights and heights of mothers were measured in the wet and dry seasons along with those of their children. Mothers were also interviewed about their own and each of their children's health (and health care), using a recall of symptoms and a record of types of treatment for the preceding four weeks. Also, a week's recall of mothers' allocation of time (time spent away from the compound) by type of activity was effected during each survey round.

Women's body weight fluctuates on average by at least 2.20 kilograms between the wet season and the dry season (Table 52). The fluctuation is about twice as high in absolute and relative terms in the upland villages as in the lowlands. Phillips, Coles, and Seaman (1982) found annual fluctuations in body weight of at least 3.46 kilograms for women, although the comparable figure for men was only 2.11 kilograms. This fluctuation in weight is a result of seasonal imbalances between the energy intake and energy expenditures of women. It has profound implications for children's health and growth performance. A reduction of this stress on mothers in the wet season by means of increased food consumption and reduced work load could be expected to have favorable effects not only for the mothers, but for their children as well, particularly the babies. With increased project involvement, women's weight fluctuations are reduced (Table 52).

Figure 7—Distribution of weight-for-age Z-scores of children aged 7-120 months, wet season 1985



Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Table 52—Nutritional status of mothers in the wet and dry seasons, by level of access to project land, 1985/86

Level of Access to Project Land	Change in Mean Weight from Wet to Dry Season	Weight-for-Height in Dry Season	Change in Weight-for-Height from Wet to Dry Season
	(kilograms)	(kilograms/ 100 centimeters)	(percent)
Lowest quartile	+ 2.9	34.6	+ 5.4
Second quartile	+ 2.6	33.5	+ 4.8
Third quartile	+ 1.7	33.2	+ 3.0
Highest quartile	+ 1.1	34.1	+ 1.8
Average	+ 2.2	33.9	+ 4.0

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

Women's reduced weight stress over the seasons may be seen as a substantial benefit of the new technology in rice (that is, the second crop) that levels out seasonal fluctuations in production and, therefore, consumption. A look at women's activity patterns sheds more light on this.

Women from lowland villages spend more time away from the compound and a higher share of that time working in field crops than women from upland villages. Rice plays a dominant role in this pattern. In the wet season, lowland women worked 61.4 percent of their available work time away from the compound, and upland women, 47.1 percent. In that main cropping season, lowland women spent 70.5 percent of their time working outside the compound in rice and a total of 78.6 percent in crop production. Upland women, on the other hand, spent 9.3 percent of their time on rice and a total of 71.7 percent in crop production. Thus, lowland women (mostly Mandinka and Serahuli) work an average of 44.0 percent more in field crops than upland women (mostly Fula and Wolof).

With increased access to the rice project—which largely coincides with village location in lowlands—women spend more of their time away in the rice fields (for example, 16.2 percent in the lowest quartile and 74.1 percent in the highest quartile [Table 53]). Accordingly, an almost linear substitution occurs with upland crops in the wet season.

To a surprisingly large extent other activities also lead women to work away from the compound during the dry season when there are no crops in the upland fields. This results in a rather low degree of seasonality in total time spent away from the compound. Thus, women from compounds with greater access to rice land in the project spend equal amounts of overall work time away from home during both seasons. Work in project rice and upland cereals is balanced with nonfarm activities. That is, nonfarm activities almost completely substitute for the reduced labor demand from upland fields in the dry season (Table 53).

How does this time allocation affect child care? Information compiled in Table 54 shows that women from compounds with more rice land in the project tend to take their older children (above 18 months) less frequently with them to the field. However, the children remain attended, if only by older children and other women in the compound. The pattern changes in the dry season when women's time is less scarce; older women rather than older children are then the main caretakers when the mother is away. Apparently, child care by older children is the less-desired choice, but the work load in the wet season often leaves no other option. Also, in the dry season, babies are much less frequently

Table 53—Allocation of women's time away from the compound, by level of access to project land, 1985/86

Time Allocation	Level of Access to Project Land: Lowest Quartile, Wet Season	Lowest Quartile, Dry Season	Second Quartile, Wet Season	Second Quartile, Dry Season	Third Quartile, Wet Season	Third Quartile, Dry Season	Highest Quartile, Wet Season	Highest Quartile, Dry Season
Time away from compound per week (in workday equivalents)	3.4	2.5	4.3	4.1	4.1	3.8	4.0	3.9
Time away from compound during day (in percent of a seven-day week)	48.6	35.7	61.4	58.6	58.6	54.3	57.1	55.7
	(percent of above time)							
Work in rice fields	16.2	6.5	51.9	54.2	61.4	62.3	74.1	61.1
Work in fields of upland crops (grains, groundnuts)	51.4	...	28.3	...	12.7	...	4.7	...
Other farming, vegetables	3.2	5.6	1.5	3.8	...	1.3	0.1	1.1
Other activities (such as fetching water, firewood, marketing)	29.3	87.9	18.3	41.9	25.9	36.1	21.1	37.8

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.
Notes: Parts may not add to totals because of rounding.

taken by the mother, but rather are left at home. Provision of child-care facilities in the wet season would assist women in increasing their labor productivity.[30]

Determinants of Nutritional Status and the Role of New Rice Production

If nutritional improvement is an objective of agricultural development, improved knowledge about the relationship between the two is of crucial relevance for appropriate program and project design. The following analysis attempts to explain children's nutritional status and its change in the context of food consumption and the health and sanitation environment of the compounds in which they live. The link to agricultural development (that is, rice) is established with the analyses in Chapters 5 and 6, in which the income and food consumption effects of technological change and commercialization were assessed (see also conceptual framework, Chapter 2, equation [8]).

The nutritional status variables to be explained in the model are Z-score values of (1) height-for-age, representing the more long-term result of food and health environment to which the child was exposed; (2) weight-for-age, representing an intermediate measure, as weight is also positively related to height (which is more a result of malnutrition and disease episodes in the past); and (3) weight-for-height, representing the short-term (acute) nutritional situation.

The explanatory variables of the model consist of four different blocks:

- Food consumption-related variables—
  calorie consumption of the *sinkiro*

[30] Day-care centers located around the rice project were an attempt to fill this apparent need.

Table 54—Pattern of child care when mother was away from compound, by age of child and season, 1985/86

Child Care When Mother Was Away[a]	Age of Child (Months)					
	0–6	7–12	13–18	19–24	25–30	31–60
	(percent of children)					
Wet season						
Total sample						
Taken with her	68.9	41.2	37.5	31.4	13.2	21.7
Left with other women in compound	13.3	17.6	17.5	28.6	13.2	29.7
Left with other women in other compound	4.4	2.0	2.5	2.9	10.5	3.4
Left with father	. . .	. . .	5.0	. . .	2.6	1.7
Left with other children	8.9	39.2	35.0	34.3	55.3	29.7
Left on its own	. . .	. . .	2.5	2.9	2.6	11.4
Left with others	4.4	. . .	. . .	. . .	2.6	2.3
By access to new fields in project						
Taken with her						
Lowest quartile	58.3	37.5	70.0	66.7	33.3	46.2
Second quartile	66.7	43.8	11.1	18.2	11.1	25.0
Third quartile	60.0	28.6	30.0	33.3	. . .	7.5
Highest quartile	77.3	60.0	33.0	. . .	. . .	. .
Dry season						
Total sample						
Taken with her	57.9	30.8	11.9	12.1	. . .	1.3
Left with other women in compound	23.7	35.9	52.4	57.6	75.0	42.7
Left with other women in other compound	2.6	2.6	2.4	9.1	. . .	4.0
Left with father	. . .	. . .	4.8	. . .	. . .	0.7
Left with other children	13.2	30.8	28.6	15.2	21.4	32.7
Left on its own	. . .	. . .	. . .	. . .	3.6	16.7
Left with others	2.6	. . .	. . .	6.1	. . .	2.0
By access to new fields in project						
Taken with her						
Lowest quartile	66.7	33.3	28.6	25.0	. . .	. . .
Second quartile	70.0	50.0	6.7	11.1	. . .	2.6
Third quartile	50.0	33.3	. . .	. . .	. . .	2.9
Highest quartile	60.0	28.6	. . .	. . .	. . .	. . .

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

[a] During the week preceding the interview.

- Health- and sanitary-related variables—
  prevalence of sickness (for example, diarrhea)
  quality of village drinking water
- Demographic environment of household—
  size of *sinkiro*
  number of children in *sinkiro*
- Individual child's demographic characteristics and history—
  sex
  age
  born in "bad" season
  child of the compound head
  mother's height

Besides these factors, account is taken of the accuracy of information obtained by controlling for data on birth dates actually documented versus those only estimated by the mother. Finally, an evaluation is made of whether the degree of participation in the new rice project has an effect beyond the determinants mentioned above. This is to test for secondary and indirect effects at work in the complex web of nutrition-consumption-health and child-care relationships. The data from both survey rounds are pooled in the model and separated by a dummy variable to account for seasonal effects besides those captured by the variables mentioned.

This leads to the model below, which is based on the following hypothesis. Increased per capita calorie consumption at the household level (CAL) also increases calorie consumption for children, who capture their own share of the greater availability. This increased consumption reduces the nutrition problem, but decreasingly so at the margin (CALSQ). If a child had diarrhea (DIAR) for an extended time preceding the survey date, its nutritional status has presumably deteriorated. An attempt is made to capture genetics (GEN) by mother's height (fathers were not included in the anthropometry survey). While short-term nutritional status is affected by diarrhea and related diseases, poor village water quality (WATER) is expected to have an adverse effect on the nutrition and health environment in which the child grows up. In large *sinkiros* (SIZE) and in *sinkiros* with a high share of small children (NCHILD), it is hypothesized that negligence in child care will have negative effects for child health and nutrition. On the other hand, it is hypothesized that children of the compound head (CHCHD) are better taken care of than others; the models test for differential nutritional performance of boys versus girls (SEX), and take account of the age-specific curvature of growth (AGE, AGESQ). As indicated by the earlier tabulations, it is hypothesized that children born in the "bad" season may suffer nutritionally (SBORN); from increased access to the rice project (RICPROJ), favorable income and consumption and, thus, nutritional effects are expected. These should be captured in the calorie consumption and in spending on health improvement. On the other hand, adverse effects are expected for women's income control and work load; time and income allocated to nutritional improvement may suffer because of that, and this effect—over and above the income consumption effect—is expected to be captured by the RICPROJ variable.

The model is thus as follows:

$$NUTSTAT_{i,s,r} = f(CAL_{s,r}, CALSQ_{s,r}, DIAR_{i,s,r}, GEN_{i,s,r}, WATER_{s}, SIZE_{s}, NCHILD_{s}, SEX_{i,s}, AGE_{i,s,r}, AGESQ_{i,s,r}, SBORN_{i,s}, CHCHD_{i,s}, VERDAT_{i,s}, RICPROJ_{s}, DRYS_{r}), \quad (17)$$

where

VERDAT = verification of birthdate,
DRYS = observation in dry season,
i = child,
s = *sinkiro*, and
r = survey round (season wet, dry).

(For variables in general terms, see preceding text; for specific definitions, see Table 55.)

Explanatory power of this type of model in terms of R^2 is low, in general because of much variance in the dependent variables, which is due to genetics and the past health and nutrition history of children not captured in the cross-sectional analysis. It is more the levels and significance of estimated parameters that are telling. From the estimation results in Table 55, the following are highlighted:

Table 55—Determinants of nutritional status

Variable[b]	Weight-for-Age Z-Scores of Children Aged 7-120 Months[a]		Height-for-Age Z-Scores of Children Aged 7-120 Months		Weight-for-Height Z-Scores of Children Aged 7-120 Months	
	Parameter	t-Value	Parameter	t-Value	Parameter	t-Value
CAL	0.0091559	2.713	9.314474E−03	2.206	4.611568E−03	1.468
DIAR	−2.50525	−2.690	−4.05504	−3.480	−0.31224	−0.360
WATER	−0.01006	−2.248	−0.02183	−3.097	4.735614E−03	1.136
SIZE	−0.71560	−1.826	0.62056	1.266	−1.38726	−3.802
NCHILD	−0.10040	−0.547	−36.18402	−1.739	17.92066	1.157
SEX	−8.18773	−1.501	−18.33278	−2.685	1.84985	0.364
AGE	1.67620	4.308	0.72466	1.488	0.92144	2.543
AGESQ	−7.69439E−03	−2.426	1.513454E−03	0.381	−6.64467E−03	−2.250
SBORN	−13.64637	−3.480	−18.33008	−2.662	−3.49221	−0.682
GEN	1.85207	4.487	2.52886	4.896	0.22410	0.583
CHCHD	17.84216	3.074	14.89253	2.050	15.53760	2.874
VERDAT	−19.99746	−3.132	−34.58969	−4.329	4.81197	0.809
RICPROJ	−109.19153	−0.740	−110.01574	−0.596	−45.46775	−0.331
DRYS	19.29197	3.507	−0.69184	−0.101	26.61881	5.197
Constant	−467.02280	−6.746	−507.38817	−5.857	−160.14683	−2.484
$\bar{R}^2$	0.164		0.162		0.072	
F-value	17.28		17.06		6.88	
Degrees of freedom	1,233		1,233		1,233	

[a] Z-scores are multiplied by 100 in this analysis.
[b] Definitions of variables:

CAL	= calories per adult-equivalent person per day from all sources, including snacks;
DIAR	= number of days of diarrhea in preceding four weeks;
WATER	= bacteria count of most-used well in village used for drinking water;
SIZE	= number of adult-equivalent persons in *sinkiro* (cooking and consumption group);
NCHILD	= number of children under 10 years of age over number of persons in *sinkiro* (ratio);
SEX	= sex of child (= 1, boys; = 0, girls);
AGE	= age of child in months;
AGESQ	= age of child in months squared;
SBORN	= if child born in "bad" season (March-August) (= 1, else = 0);
GEN	= height of mother in centimeters;
CHCHD	= if child is son or daughter of compound head (= 1, else = 0);
VERDAT	= if date of birth is verified by record (= 1, else = 0);
RICPROJ	= size of lands in new rice project in hectares of irrigated land equivalent per adult-equivalent person; and
DRYS	= if observation in dry season (= 1, else = 0).

• Increased food energy consumption reduces children's nutrition problem as expected.[31] A 10 percent increase in calorie availability per capita in the *sinkiros* significantly increases the weight-for-age Z-score at the sample mean by 0.28 (2.4 percent). Increased calorie availability clearly has a very favorable effect for children's nutritional improvement. The respective elasticities of Z-scores with respect to calories are high

[31] No significantly decreasing effect is found at the margin. The specification was therefore changed and CALSQ was dropped.

for all three nutritional status indicators. They range between 0.24 and 0.26 for the three indicators calculated at sample means.

- High prevalence of diarrhea is associated with a reduction in nutritional status. This is significant for height-for-age and weight-for-age, although not for weight-for-height. The latter part of this finding is curious, since one would expect the prevalence of diarrhea measured during the survey to have the greatest effect on the short-term indicator and less effect on the long-term anthropometric characteristic of the child. It may be, however, that the diarrhea variable represents underlying unhygienic conditions in the home.
- Children from villages with unclean drinking water—that is, where a high bacteria count was found in the water sample—were significantly more stunted (see height-for-age model). Frequent episodes of water-borne diseases can be assumed to be the cause of this.
- The parameter of mother's height, which is seen as a genetic indicator, contributes to explaining child's height-for-age and weight-for-age variance as expected.
- Increasing *sinkiro* size has a significantly negative effect on children's weight-for-age and weight-for-height. As the calorie consumption model showed, increased *sinkiro* size was associated with reduced calorie intakes per adult equivalent. Moreover, observations in large compounds (which tend to have the largest *sinkiros*) suggested that child care was particularly insufficient in these larger units. This implies that, while there may be positive scale effects in food consumption, there may be negative ones in producing child health and nutrition.
- Contrary to many Asian examples, boys here are found to be less well off than girls (height-for-age, weight-for-age). Yet there is a different bias; children of the compound head are significantly better off than others in the same family unit. Distribution of investment in children's health and nutrition is obviously not equal within compounds.
- Both weight-for-age and height-for-age are adversely affected in the long run if a child is born late in the dry season or early in the wet season. Children born in these periods are on average 8 percent more stunted (their estimated height-for-age Z-score is 8 percent less than the average).
- There are no indications that (degree of) access to the rice project has a negative or positive effect on nutrition beyond any of the factors already included in the model through which the indirect income-consumption effects show their positive effect on nutrition.
- The control variable that identifies the children without a written birth record suggests that mothers systematically tend to underestimate their children's age. A separate estimation of the same model for all the children with birth records did not significantly change the overall model results from those presented in Table 55. It is also noteworthy that mothers' height, which is partly genetically determined, has a highly significant effect for children's height and weight. The ethnic differences of height in the location are supposedly captured through this variable.
- Seasonality in weight loss is not fully explained by the consumption- and health-related variables in the model. Nutritional status in the wet season is estimated to be worse than in the dry season even after consumption and health variables are controlled for (DRYS).

In addition to the explanation of children's nutritional well-being, an attempt is made here to explain mothers' nutritional status in a model.

The dependent variable of this model is the weight-for-height (MWH; kilograms per centimeter) of mothers of the children in the sample. The considerable variance and seasonal fluctuation of women's weight, which is reflected in this variable, was described earlier. These differences and fluctuations are hypothesized to be determined by women's food consumption levels (CAL) and by energy expenditure, as indicated by work load (WORKL). Only a rough indication is possible given survey data that cover women's activities for only one week in each of the two seasons. Above that, current health (SICK), pregnancy status (PREG), and individual status characteristics (compound head's wife, CHHUSB) are controlled for. The model is as follows:

$$MWH_{i,s,r} = f(CAL_{s,r}, CALSQ_{s,r}, WORKL_{i,s,r}, SICK_{i,s,r}, PREG_{i,s,r}, NOCHL_{i,s,r}, CHHUSB_{i,s}, DRYS_r), \tag{18}$$

where

NOCHL = number of children born,
CHHUSB = woman is wife of household head,
DRYS = dummy variable for dry season is 1,
i = woman,
s = *sinkiro*, and
r = survey round.

(For specific definitions of all variables, see Table 56.)

The results of the multivariate analysis show that household food energy consumption has a positive effect on mothers' nutrition, but the food consumption effect decreases at the margin.

Table 56—Determinants of mother's nutritional status: regression model

Variable[a]	Parameter	t-Value
CAL	3.735987E−03	3.524
CALSQ	−2.79431E−09	−1.564
WORKL	−8.47798E−04	−1.151
SICK	−6.21542E−03	−1.691
PREG	0.04032	4.496
NOCHL	3.735987E−03	3.524
CHHUSB	8.377180E−03	2.373
DRYS	0.01059	3.002
Constant	0.30493	16.824
$\bar{R}^2$	0.080	
F-value	7.80	
Degrees of freedom	716	

[a] Definitions of variables:

CAL = calories per adult-equivalent person per day from all sources, including snacks;
CALSQ = calories per adult-equivalent person per day from all sources squared;
WORKL = time spent working away from compound in day equivalents over one-week period;
SICK = if woman was sick during preceding four weeks (= 1, else = 0);
PREG = if woman is pregnant (seven months or more) (= 1, else = 0);
NOCHL = number of children born;
CHHUSB = woman is wife of a compound head (= 1, else = 0); and
DRYS = dummy variable for dry season (= 1).

The nutritional status of women who are wives of compound heads is significantly better than others. This indicates an unequal distribution of nutrition and health benefits among a compound's women, which was also found to be true for children. The seasonal effect on women's nutritional status is confirmed; women are significantly better off in the dry season.

To sum up, major findings of the nutritional effects of technological change in rice production include the following:

- The project raised household income, and thus calorie consumption, which in turn substantially improved the nutritional status of children. The shift in income control away from women has, however, somewhat limited the beneficial consumption effect.
- Mothers' weight loss in the wet season, which is not only a health and nutrition problem for the individuals but also indirectly for their children as it relates to low birth weight, was found to be reduced with increased access to the new rice land.
- The greater their access to the rice project, the more frequently mothers take their smallest children with them to the rice fields in the wet season. Since proximity to the swamps is associated with more sickness in children (that is, fever), there is a health problem that requires attention;[32] the solution probably lies in appropriate supplementary program components for child-care support in the villages.

[32] The percentage of children under five years of age found sick during the preceding four weeks of the recall period was 6.1 percent higher in the lowland villages than in the uplands, and the duration of sickness was on average 7.6 days in the villages close to the river compared with 4.8 days in the upland villages.

8

CONCLUSIONS FOR PROGRAMS AND POLICY

From this West African case study, generalizable conclusions are sought as guidelines for programs and policies designed to improve household-level food security and nutrition through technological change in agriculture and enhanced market integration. The attempt to generalize is made by confronting specific study findings with broader policy objectives and constraints. No attempt is made to outline a set of general prescriptions.

With the current situation of difficult economic adjustment in many African countries, programs need to be rigorously designed toward saving or generating foreign exchange, not creating a fiscal burden. Furthermore, in view of rising urban unemployment, there needs to be a focus on expanding rural labor demand and increasing productivity in agriculture (Mellor, Delgado, and Blackie 1987). These criteria may not necessarily be compatible with a narrowly defined focus on food self-sufficiency at the national level. For example, major irrigated rice schemes may use up resources that would make more rice—or other cereals—available if they were directed to other uses: minor irrigation, rainfed rice, other food crops, or exportable crops earning foreign exchange used to import food.

Agricultural growth fostered by technological change is documented in this study as a powerful force able to contribute toward the fulfillment of the above objectives and ultimately to the alleviation of poverty. While a strong positive relationship was established in this research between increased income, rising food consumption (from deficit levels), and nutritional improvement, there is ample scope for agricultural program design to maximize these welfare effects of agricultural growth by appropriate policy coordination in the fields of agriculture, infrastructure, and health.

Research on the rice project considered here has clearly shown that a narrowly focused promotion of output in one crop, through subsidized irrigation, did achieve increased production. However, this was achieved at high costs of investment and high opportunity costs of labor. The latter resulted from considerable output forgone from competing crops (other cereals and groundnuts) because labor, having high marginal productivity, was withdrawn from them.

Furthermore, it is shown that an understanding of the wider context of nutrition-deficiency problems and their causes is required in order to effectively mobilize program components for improvement of food security. The results stress that this should include paying more attention to seasonality in income and food availability, to women's work load, to the health situation, and to sanitation (water quality).

This is not to argue that individual projects should singlehandedly attempt to be "do-everything projects." Quite the contrary, given the past failures of many broad-based rural development programs in Africa. The research results stress, however, the importance of comprehensive policy coordination for rural poverty alleviation. To achieve effective nutritional improvement as a result of agricultural development programs, a complement in the form of health- and nutrition-related policies that combine long-term development concerns with a targeted short-term impact on nutrition is required. In countries dependent on farming, such as The Gambia, successful agricultural programs and policies have to provide the resources to fund such complementary measures and to make them sustainable in the rural sector.

Choice of Program Focus in Agriculture

Several factors may speak for a focus on rice in agricultural development programs in this West African setting: the irrigation-seed-fertilizer technology to promote rice is well known; rice is the main marketed cereal in rural and urban Gambia; in a country that imports 35 percent of cereals consumed, the import-substitution effect is favorable for the foreign exchange situation insofar as the chosen technologies permit incremental production at low foreign exchange cost; rice is particularly important as an income source for poor farmers in this area; and the rural poor get more calories from rice than do the upper-income groups.

However, the analysis of labor productivity by crop suggests that considerable scope exists for a multicrop focus rather than a single-crop focus. The analysis of the productivity of upland crops underlines the potentials of a policy that would move the agricultural production frontiers more broadly with functioning input delivery systems; that is, a fertilizer cum labor-saving implement program coupled with an effective rural credit scheme (explicitly open to women farmers or with a specific women's branch). Program planners need to be aware that the promotion of crops that compete with rice for labor and other resources (millet, maize, groundnuts) through broad-based policies for improved input delivery systems will further increase the opportunity cost of rice production. This calls for more attention to competition between crops for scarce labor resources and a less-narrow focus on physical output growth in a single crop.

The main commercialization effect of the new rice crop is driven on the input side by loan repayment requirements for fertilizer, seed, water charges, and land preparation services. The second effect is an expanding market for hired labor. The third is the marketed surplus from the new crop, which, however, was found to be rather low. While marketed surplus was found to be output- and price-elastic as expected, local infrastructure (that is, proximity to the road/markets) had a favorable effect over and above these elasticities. This stresses the potential role to be played by infrastructure in improving agriculture's integration into the exchange economy.

Choice of Technology for Rice

Since scarce water resources in the dry season limit the development of fully water-controlled rice, it is argued that more emphasis on the partly water-controlled rice technology for the wet season would be appropriate. Even if this type of rice does not have the positive smoothing-out effect on seasonal cereal supplies that is provided by a dry-season crop, it is still a more secure means of producing cereals than the purely rainfed upland farming. Women are more involved in this partly water-controlled technology, which appears second-best in terms of returns to labor from a farmer's perspective. Currently, this is largely because of the differential subsidies embodied in irrigation infrastructure allocated to the two rice technologies. The cost of production in this technology, however, has to come down substantially to be viable. Land-development cost in larger perimeters makes tidal and improved rainfed rice currently even more expensive than fully water-controlled rice in the Jahally-Pacharr project and not competitive with the import alternative. Smaller perimeters with less land-leveling cost per unit of area could probably sharply reduce costs.

The choice-of-technology issue in rice is, however, not simply a question of choice between technologies X and Y. In each type of technology there is a substantial proportion of farmers who produce rice competitively (compared with equivalent import prices) and others who do not. Mean values can provide only a rough guide. A key issue is to identify, through efficient monitoring, the technical constraints that keep certain farmers at the upper end of the distribution of unit cost of production, and thereby find ways to move these costs downward. Again, this means rejecting the narrow approach of focusing on yield levels per unit of land instead of focusing on returns per unit of labor.

Under erratic, unfavorable rainfed conditions, owners of small, irrigated rice plots with substantial upland crop enterprises are caught up in a difficult decisionmaking process for farm production because of increased competition for their scarce labor resources. With labor productivity-increasing measures in upland crops, this competition is likely to be further intensified in a situation of land abundance, as noted above. The climatic difficulties of wet weather in July-August and cold weather in November-January require, for profitable double-cropping of irrigated rice, a high degree of timeliness in the management functions of farmers and schemes for accurate sequencing of the cropping program, and organization and mobilization of production support services and inputs. The difficulties in these management functions are compounded by complex crop-mix patterns. Although these accentuating forces impinge directly on the wet-season irrigated crop more than on the dry-season crop, their effects are transmitted through the crop-sequencing process into the dry-season crop.

Protection and Enhancement of Women's Productive Role in Agriculture

The Jahally-Pacharr project has a strong focus on protecting and enhancing women's role in crop production. Despite considerable efforts by program planners to maintain women's access to the new rice technologies, women farmers ended up mainly with access to the lower-level, lower-yielding technologies. The men, on the other hand, took control of the highest-yielding rice technology, which consequently increased their returns to labor much more than was possible for the women. The increased food security now provided by the new technology did not exist before in this location. Growing the new rice crop required a shift of male labor resources under the authority of compound heads from traditional *maruo* production in upland fields to the new rice fields. It was thus perhaps inevitable that the rice ended up under the control of compound heads. In view of this experience, how can women's participation in technological change be improved? Briefly, the lessons are these:

1. The selection of a "women's crop" for promotion does not guarantee that the new form of crop production will benefit women more than men.

2. Project managers cannot guarantee the protection of traditional production arrangements while at the same time fundamentally changing the nature of that production.

3. Women are much more involved in independent cash crop production (cotton, groundnuts) than has generally been acknowledged. Yet their access to means of increasing their labor productivity (fertilizer, tools) in these crops was less than men's. This finding indicates that there is a potential for women to be included in the mainstream of the agricultural development process through a program of upland cash crop promotion as well as the improvement of swamp rice, taking account of women's labor constraints.

Women's interest in the new rice technologies and in upland crops would be safeguarded and enhanced by increased access of women to credit for the short-term financing of productive inputs. It is not just fertilizer and seed acquisition that is required, but transport, on-field threshing machines, village-based milling machines, bridging of short-term labor bottlenecks by labor hiring, and so on. Village-specific women's groups that exist traditionally in many of the communities could form the basis for cooperative organs through which loan security might be provided.

The suggested move away from promoting a single crop (rice) to promoting improved labor productivity in rice *and* in upland crops together would further reduce the pressure for competition between men and women in rice production and thus permit women to capture a larger share of the benefits accruing from technological change.

Allocation Policies for Irrigated Land: A Food-Security Perspective

Complex land tenure issues arise when highly valued irrigated land is developed in an area where there is abundant (low-value) land supply for rainfed agriculture. Who should get access to the new land, to what extent, for how long, and under what conditions? An auction approach to land distribution cannot be recommended on equity grounds because the poor do not have effective access to capital markets. Any rationing criteria have to be complex. Original rights to land taken over by the scheme and household labor resources are key factors.

The distribution of new land among large numbers of villages and among many compounds within each village had a favorable effect in the Jahally-Pacharr case. The benefits of the dry-season crop for reduced calorie deficiency during the wet (hungry) season were well spread out among the local communities. There are no indications that potential returns to scale were lost by this approach. Traditional acquaintance with irrigated agriculture is not necessarily a recommended criterion for land distribution, since farmers from villages that had little experience in rice production obtained the highest yields in this project by carefully following production recommendations.

The development of small-scale irrigation schemes that provide farmers with a less drought-affected, additional income source in the form of food has obvious advantages for food security. Against the background of the very low savings rates of the rural poor, this food-security effect is particularly relevant in this West African environment where rural capital markets are thin.

With large year-to-year fluctuations in rainfall, labor productivity in rainfed agriculture fluctuates similarly, and this instability is transmitted to irrigated rice schemes through the labor supply to such schemes. Years of good rainfall are, therefore, bad for yields in irrigated rice, as labor is not forthcoming so much as in years of drought. This is reflected by the drop in yields in fully water-controlled rice from 6.6 to 5.2 tons from the drought year 1984 to the year 1985, which had reasonably good rainfall. The fixed cost per unit of output in irrigated rice is thus higher in years of good rainfall. Yet, as long as crop price levels and ratios are not much distorted, the resulting yield fluctuations due to the shifting of labor between crops are a consequence of efficient reallocation of resources.

A focus on stable yields in schemes under those circumstances would be misleading. Schemes have to live and cope with the phenomenon of fluctuations in this region. With a wider distribution of land in a scheme—that is, smaller plots per household—the transmitted fluctuation "problem" increases, as the income from irrigated rice becomes more marginal for each household. Yet the food-security benefit at the household level is certainly increased with a wider distribution. This food-insurance function of irrigated rice at locations where other means for improved household-level food security are scarce argues for broad access of villages and for small allocations of irrigated land per household. Choice of varieties (that is, fast-maturing ones) may ease the fluctuation problem to some extent.

Income of the Poor and Consumption Linkages

This study has stressed that the substantial differences in per capita income between households in rural Gambia are long-standing. A targeting of productive resources and employment toward the poor is thus called for in programs aimed at nutritional improvement through economic development.

Additional income generated by the poorer households translated into more food-energy consumption and more nutritional improvement than in the rest of the population. Calorie deficiency is largely confined to the lowest 25 percent on the income scale. These 25 percent are forced to adjust their calorie consumption downward in the hungry season, while the rest of the population does not. In principle, this suggests that emergency food aid programs could be targeted at much smaller groups in the rural areas than is frequently assumed in The Gambia. Administrative targeting, however, is not easy in this environment. It requires considerable knowledge about the specific communities. Local administrative capacities are too limited for such tasks.

Low income in this land-abundant setting is caused mainly by low labor productivity in agriculture, which in turn is a result of inability to acquire productivity-enhancing inputs and tools. Any additional income, derived from traditional cash crops (such as cotton and groundnuts), staple foods, or nonagricultural income and transfers (remittances), is expended equally on food and nonfood consumption, regardless of the income source. Whether the income is in the form of cash or food does not make any difference to changes in the food-energy consumption of households. This suggests that agriculture-based programs for poverty alleviation and nutritional improvement in this area do not need to be limited to food crop promotion, but need to focus on the most effective way of promoting income growth among the poor, which may well be through technological change in food production.

Reinforcing Effects of Development on Nutritional Improvement

Increased income translating into food consumption was found to be a powerful force for the nutritional improvement of malnourished children in The Gambia. However, the complex web of nutrition and health interactions suggests that the improvement of health should be a direct target linked with raising consumption levels through income. Rural health services need to be upgraded and moved closer to areas of demand/need in order to enhance the favorable income-consumption linkages for nutritional improvement. A practical aspect of this is unclean village water supplies (found to be a significant factor in nutritional deterioration), which should be a priority focus of complementary programs of rural development. The burden on mothers' time for child care in the wet season, increasingly strained by extra work in rice, requires a creative, village-based response. Child-specific interventions, parallel with agricultural development, should focus on children of low birth weight and the factors causing a nutritional deterioration of children aged one to three years. This is where the key problem of child malnutrition lies.

As confirmed in this study, agricultural programs and policy can directly affect the symptoms and patterns of malnutrition. The positive effects of agricultural development can, however, be strengthened by effective public health services. These services should be coordinated in a strong national system that is designed to tackle, as a priority, the preventative and curative needs of the rural poor. A project-by-project approach to health delivery can easily lead to inefficiency and injustice.

APPENDIX: SAMPLE SELECTION AND SURVEY DESIGN

Sample Selection

In the project area itself, eight villages were identified in a two-stage random sample selection. The Jahally-Pacharr Project Management Unit provided a complete list of project villages with information about village size and the project rice land allocated to each village. Eight villages were chosen from this list by stratified random sample. Stratification criteria were (1) size of the village (that is, number of households), (2) distance from the Jahally and Pacharr swamps, and (3) ethnic group. The profile of the selected villages (Table 57) shows the representation of both large and small villages around the two project sites (Jahally and Pacharr swamps), of ethnic groups, and of different degrees of involvement in the project.

Two additional villages located outside of the project area were chosen randomly from other rice-growing villages to broaden the variability of observations and to represent the situation in the Jahally-Pacharr area before the project started. Both villages are involved in traditional swamp rice production or older pump-irrigated rice schemes or both. Choosing only two villages outside the project area was considered sufficient, as village and household participation within the project area already showed great variability.[33]

In the second stage of sample selection, a baseline survey of all households in the selected villages was carried out to provide basic information about household demography and project involvement. Roughly three out of four households in each village were chosen randomly from this survey for interviewing. As described in detail in Chapter 3, the "households" in the study area can be very large units (compounds), frequently with 40-80 people. Averages at village level range between 7.9 and 16.5 persons in the sample villages (Table 57). The random draw of households at village level mentioned above refers to compounds. A total of 168 compounds was drawn into the sample. However, in some of the Wolof, Mandinka, and Serahuli compounds, most of which are very large, the compounds were subdivided into subunits of decisionmaking and management of consumption and production affairs. In special interview sessions with female and male compound leaders, the compound structures were evaluated and, where appropriate, compound subdivisions were taken into account. In these cases when compounds were subdivided, all units were maintained in the survey to permit flexible aggregations if required for specific analytical questions. The subdivision of the compounds resulted in a total of 214 household units (in the case of Mandinka villages, usually referred to as *sinkiros*).

The study sample compounds from the eight villages in the project represent about 10 percent of the total compounds participating in the project and also about 10 percent of those compounds involved in the fully water-controlled rice production. Fifty-two percent of the sample compounds have an average field size of pump-irrigated rice exceeding 0.25 hectare (equivalent to one-half of a plot). The equivalent percentage

[33] Certainly, a larger and more regionally distributed sample is desirable. Logistical constraints prohibited that in the 1985/86 survey, but in a follow-up survey in 1987/88 the sample was extended to three villages on the north bank of the Gambia River.

Table 57—Profile of sample villages and sample compounds, 1985/86

Village	Number of Compounds in Village	Number of Compounds Selected for Survey	Main Ethnic Group	Distance from Project Land	Average Size of Sample Compounds	Area of Fully Water-Controlled Project Land	
						Per Compound	Coefficient of Variation
				(kilometers)	(persons)	(hectares)	
Njoben	50	28	Wolof	11	15.3	0.16	0.70
Pacharr	5[illegible]	33	Mandinka	4	16.5	0.49	0.78
Dasilameh	50	36	Mandinka	4	9.3	0.63	0.55
Sinchou Abdou	15	11	Fula	4	8.8	0.22	0.86
Kussalang	18	13	Fula	11	7.9	...	...
Sare Samba Sumali	16	10	Fula	8	9.5	0.16	0.96
Sare Bala	7	7	Fula	6	8.4	0.14	0.11
Sukurr	10	8	Serahuli	3	16.1	0.56	0.32
Teneng Fara	12	11	Mandinka	...	9.8	...	...
Touba N'ding	12	11	Mandinka	...	8.1	...	

Source: 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

figure for households in the total project area is 45 percent. The average field size (rice) of the sample farmer is slightly lower (0.56 hectare) than in the whole population (0.69 hectare). Some of the sample villages (those in the Pacharr swamp area) also have access to a considerable amount of partly water-controlled (tidal-irrigated) land in the project.

Averages of key indicators show that the selected sample comes close to being representative of the study area as a whole (Table 58).

Sample Design and Data Collection

The household survey was executed during the rainy season of 1985 (August-October) and during the dry season of 1986 (January-March). The data collection was carried out by a carefully trained enumerator team, closely supervised by IFPRI staff on a daily basis. IFPRI staff and enumerators lived in the villages throughout the surveys. Half of the enumerator team were women, who generally interviewed women.

Data collection was tailored to examine the complex production and food consumption situations in the households. Considerable time was invested in designing and pretesting questionnaires on production, consumption, and nutrition that were appropriate to the local conditions and the specific research task. The questionnaires were precoded for direct data entry after completion. The set of questionnaires for each survey round consisted of the following:

1. A *demographic questionnaire,* which identified persons belonging to the household and its demographic characteristics (family relationships, household organization) and those responsible for crop production or owning livestock or both. This questionnaire formed the basis for all other questionnaires by identifying the appropriate respondents for specific issues, such as head cooks of consumption units (for consumption survey), all mothers with children under 10 years of age (for nutrition and health survey), all adults (for expenditure and nonagricultural income survey), all farmers (for agricultural production and marketing survey), and compound heads (for storage survey).

Table 58—Project land farmed, by compounds and area

Compounds/Area	Total Project Area	Sample Compounds in Project Area with Access to Project Land
Number of compounds	1,414	152
Fully water-controlled area in project (hectares)	548.00	54.50
Area per compound (hectares)	0.39	0.36
Villages with high involvement in project[a]		
Number of compounds[b]	642 (45)	79 (52)
Area per compound (hectares)	0.69	0.56
Villages with low involvement in project[a]		
Number of compounds[b]	772 (55)	72 (48)
Area per compound (hectares)	0.13	0.14

Sources: Jahally-Pacharr records and 1985/86 survey by International Food Policy Research Institute/Planning, Programming, and Monitoring Unit, Ministry of Agriculture, The Gambia.

[a] High = more than 0.25 hectare per compound of fully water-controlled land; low = less than 0.25 hectare per compound of fully water-controlled land.

[b] Numbers in parentheses are percentages.

Because of the complexity of intrahousehold organization, much of the information was gathered on an individual-by-individual basis and later aggregated to the appropriate unit of observation (for example, individual snack foods of members of a cooking unit).

2. The *food consumption questionnaire,* which covered day-by-day, weekly, once-a-season, and more long-term recalls of food acquisition and consumption, plus eating and cooking arrangements.

3. The *health and nutrition questionnaire,* which was applied to all mothers or caretakers of children under 10 and included specific demographic, child-care, and child-feeding information on a child-by-child basis; morbidity recalls for children and mothers/caretakers; mortality information; mothers' time allocation (when working away from compound), and anthropometric measurements of children and mothers recorded in each round (weight and height).

4. The *expenditure and nonagricultural income questionnaire,* which applied to all relevant adults and included a week's snack food survey; a week's survey of frequent nonfood purchases; a long-term (seasonal) survey on large expenditures, using a list of 60 expenditure items or groups of expenses; nonfarm income in cash and in kind; and remittances.

5. The *agricultural questionnaire,* which applied to all men and women farmers and examined field-by-field data on inputs, production, use of crops for the relevant seasons, livestock, and vegetables. Institutional arrangements of production (communal, individual) were assessed. Labor inputs were enumerated on a field-by-field and operation basis by sex. Land use was measured in a subsample of 10 percent of fields to cross-check with recall information. Ethnic group-specific and compound-specific units of volume measures were used for quantities of output produced and marketed or otherwise disposed of. Prices for all major transactions of outputs and inputs during the recall periods were similarly measured in the units most convenient to households.

6. The *storage questionnaire,* which was carried out with the household head and other relevant adults, involved quantifying current stock levels by crop and by storage responsibility (individual and communal storage).

The complex surveys required considerable time and effort by the enumerator staff. A key to successful completion was the excellent rapport developed in the villages by the survey supervisors. For example, some of the senior staff were allocated fields by village headmen, and they organized their own upland field crop production during the survey. Few households dropped out of the survey.

In-Depth Study

Because of the diversity of household organization in this setting, an in-depth study (Webb 1989) on decisionmaking and resource control inside the household unit was added to the structured main survey. This more detailed analysis focused on a 10 percent subsample of the large sample households. The in-depth study provided micro-level data necessary for an assessment of the distributional effects of technological change and commercialization within the complex social networks that make up the Gambian household. Through closely supervised questionnaire surveys, participant observation, and a detailed accounting of labor flows, an attempt was made to identify the individuals most affected by the introduction of new agricultural technology.[34] This intrahousehold information was fed into the large-scale survey, permitting insights to be followed up in the field.

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[34] For a fuller account of this in-depth survey's design, implementation, and results, refer to Webb (1989).

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