

Measurement and determinants of rural poverty

Household consumption patterns and food poverty in rural Sudan

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A logit model and Engel curves are used to study the determinants of food poverty and composition of household consumption among the tenant farmers of the Rahad Scheme in Sudan where land is equally distributed. The data support the permanent income hypothesis, whereas Engel's assumption of declining food shares with increased total spending did not hold for the present sample. The logit analysis provides strong evidence for the important influences of better access to productive assets other than land, smaller-sized families, higher non-farm earnings and farming experience on reducing the probability of food poverty on the scheme. Policies directed towards the provision of better family planning, education, extension, increased on- and off-farm employment and improved infrastructure for higher labour mobility can make for effective poverty alleviation programmes in this sector.

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¹World Bank, *World Development Report*, Oxford University Press, New York, NY, 1980; World Bank, *World Development Report*, Oxford University Press, New York, NY, 1983.

²J.P. Behrman and A.B. Deolalikar, 'Will
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Alleviation of relative and absolute poverty has become a major component of development planning over the last two decades.¹ With inequality and the number of poor growing larger in many developing countries, the previous thinking that favourable distributional effects and reduced levels of poverty are the sure outcome of economic growth had to change.² Accordingly, a shift was made towards poverty-focused development strategies such as the 'redistribution with growth' and 'basic needs' approaches in the early 1970s.³ Several studies have been conducted since then to provide policy information to development planners on the severity and determinants of poverty and inequality and to identify target groups and their characteristics.⁴

One major indicator of poverty has been the level of nutritional status measured by energy and protein intake.⁵ Other criteria were also used to identify the poor based on household income,⁶ employment,⁷ asset holding⁸ and food consumption expenditures.⁹ Several methods of measuring poverty and inequality at an aggregate level employing these criteria have been developed.¹⁰ Recently, a food poverty index based on Engel's function for food commodities has been used to measure the level of nutritional poverty in Kenya.¹¹ Factors associated with the incidence of poverty in many countries were identified and analysed in a large number of studies using mainly descriptive methods.¹² Few others, however, applied analytical techniques to study the determinants of poverty.¹³

While there is a large body of literature on the determinants of poverty in south and south-east Asian countries,¹⁴ very few attempts have been made in their African counterparts.¹⁵ With the recent emphasis on relieving food crisis and reducing the severe consequences of famine and malnutrition on the poor, there is an urgent need for researching poverty problems in Africa. This is particularly so in countries that are seriously stricken by drought and famines, such as Sudan and Ethiopia. The process of identifying the poor as target

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developing country nutrition improve with income? A case study for rural South India', *Journal of Political Economy*, Vol 95, No 3, 1987, pp 108-138. See also G.S. Fields, 'Changes in poverty and inequality in developing countries', *World Bank Research Observer*, Vol 4, No 2, 1989, pp 167-185.

³H. Chenery and M. Ahluwalia, *Redistribution with Growth*, Oxford University Press, New York, NY, 1974; P. Streeten, S. Burki, Mahbub Ul Haj, N. Hicks and F. Steward, *First Thing First: Meeting Basic Human Needs in Developing Countries*, World Bank, Washington, DC, 1984; World Bank, *Poverty and Hunger: Issues and Options for Food Security in Developing Countries*, World Bank, Washington, DC, 1986.

⁴V.M. Dandekar and N. Rath, *Poverty in India*, Indian School of Political Economy, Bombay, 1971; A.R. Khan, 'Poverty and inequality in rural Bangladesh', in K. Griffin and A.R. Khan, eds, *Poverty and Landlessness in Rural Asia*, International Labour Organization, Geneva, 1983; D. Ghai and S. Radwan, *Agrarian Policies and Rural Poverty in Africa*, International Labour Organization, Geneva, 1983; J. Greer and E. Thorbecke, *Patterns of Food Consumption and Poverty in Kenya and Effects of Food Prices*, International Labour Organization, Geneva, 1984.

⁵S. Reutlinger and M. Selowsky, *Mainnutrition and Poverty: Magnitude and Policy Options*, Johns Hopkins University Press, Baltimore, MD, 1976; P.V. Sukhatme, 'Poverty and mainnutrition', in P.V. Sukhatme, ed, *Newer Concepts in Nutrition and Their Implication for Poverty*, Maharashtra Association for the Cultivation of Science Institute, Pune, 1982; T.N. Srinivasan, 'Undernutrition: concepts, measurements and policy implications', in S.R. Osmani, ed, *Nutrition and Poverty*, Oxford University Press, Oxford, UK, 1988.

⁶T.N. Srinivasan and P.K. Bardhan, *Poverty and Income Distribution in India*, Statistical Publishing Society, Calcutta, 1974; A.K. Sen, 'Poverty: an ordinal approach to measurement', *Econometrica*, Vol 43, No 2, 1976, pp 153-169.

⁷P. Visaria, 'Poverty and unemployment in India: an analysis of recent evidence', *World Development*, Vol 9, No 3, 1981, pp 141-159; K. Sundaram and S.D. Tendulkar, 'Toward an explanation of inter-regional variations in poverty and unemployment in rural India', in T.N. Srinivasan and P.K. Bardhan, eds, *Rural Poverty in South Asia*, Columbia University Press, New York, NY, 1988, pp 316-362.

⁸S.K. Sanyal, 'Trends in land holding and poverty in rural India', in Srinivasan and Bardhan, *op cit*, Ref 7, pp 121-153; M. Lipton, *Land Assets and Poverty*, Staff Working Paper, World Bank, Washington, DC, 1980.

⁹J. Greer and E. Thorbecke, 'A methodology for measuring food poverty applied to

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groups and achieving a better understanding of the determinants of poverty as policy instruments for development planners is crucial for designing effective poverty alleviation programmes. This is an objective to which the present study attempts to contribute.

A recent study in Sudan has found that unequal access to capital assets is the main source of inequality and relative poverty among rural households even when land and irrigation water are equally distributed.¹⁶ The present research utilizes data collected from the same farm households to study food poverty in the Rahad, the second largest irrigation scheme in Sudan. While supply-side effects are not systematically analysed in the present study, the influences of important supply forces such as access to productive assets, size and quality of human capital, source of income and consumption demand on the probability of being poor are examined. Engel curves and food poverty indices are constructed and the determinants of household consumption patterns and nutritional intake are analysed. Poor farmers are identified and the contribution of various social and economic factors to the probability of being below the poverty line is then measured using a logit model.

The results indicate that 34% of tenant households in the Rahad could not afford a nutritionally adequate diet, with severity of poverty in the scheme measured at 0.021. The size and social status of the farm family proved important in explaining household consumption behaviour. Less powerful influences were observed for the source of income and the proportion of dependants. Better access to productive assets, smaller families, longer farming experience and increased off- and on-farm employment opportunities were found to reduce the probability of falling below the poverty line. Several policy options are discussed for effective poverty alleviation programmes.

The remaining sections of the study are organized as follows. A description of the model analysing the budgetary expenditure patterns of the farming households and a brief discussion of the variables and data used are given in the next section along with the model results. Then the method of measuring food poverty is presented along with the estimates of various poverty indices for the study households. The determinants of food poverty are analysed using a logit model, and the last section summarizes the empirical findings and discusses the policy implications for the study area.

Household expenditure patterns

This section extends Working's form of Engel curves to measure the effects of other household characteristics on the composition of household consumption.¹⁷ The following model is used to estimate demand elasticities for the Rahad tenants.

$$W_i = \alpha_i + \gamma_i \ln x + \sum_{ij} \beta_{ij} \ln Z_j \quad (1)$$

where γ_i measures the Engel elasticity of the share of expenditure on good i (W_i) with respect total consumption expenditure (x), controlling for the effects of other household variables (Z_j). Attractive features of Working's form are demonstrated by Deaton and Muellbauer.¹⁸ The significance of incorporating other household characteristics in explaining consumption patterns, on the other hand, is an old concern in demand analysis in which there has been revived interest lately.¹⁹

Six commodity groups are used in the system of share equations given

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Kenya', *Journal of Development Economics*, Vol 24, No 1, 1986, pp 59-74.

¹⁰Sen, *op cit*, Ref 6; N.C. Kakwani, 'On a class of poverty measures', *Econometrica*, Vol 48, 1980.

¹¹Greer and Thorbecke, *op cit*, Ref 9.

¹²S. Anand, 'Aspects of poverty in Malaysia', *Review of Income and Wealth*, Vol 2, No 2, 1977, pp 112-124; M.S. Ahiwalia, 'Rural poverty and agricultural performance in India', *Journal of Development Studies*, Vol 14, No 2, 1978, pp 298-323; A.K. Sen, *Levels of Poverty: Policy and Change*, Staff Working Paper No 401, World Bank, Washington, DC, 1980, p 91.

¹³P.K. Bardhan, *Land, Labour and Rural Poverty: Essays in Development Economics*, Columbia University Press, New York, NY, 1984; R. Gaiha, 'Poverty, technology and infrastructure in rural India', *Cambridge Journal of Economics*, Vol 9, 1985; D Heien, Lovell S. Jarvis and F. Perali, 'Food consumption in Mexico: demographic and economic effects', *Food Policy*, Vol 14, No 2, May 1989, pp 167-179.

¹⁴Sanyal, *op cit*, Ref 8; Lipton, *op cit*, Ref 8; H.S. Shergill, 'Agrarian structure as a factor in rural poverty: some cross section evidence', *Economic and Political Weekly*, Issues on Agriculture, A-9-A-12; International Labour Organization, *Poverty and Landlessness in Asia*, ILO, Geneva, 1977.

¹⁵Greer and Thorbecke, *op cit*, Ref 4.

¹⁶R.M. Hassan, L.B. Fletcher and S. Ahmed, 'Unequal wealth accumulation and income inequality in a unimodal agriculture: Sudan's Rahad irrigation scheme', *Journal of Development Studies*, Vol 26, No 1, 1989, pp 120-130.

¹⁷H. Working, 'Statistical laws of family expenditure', *Journal of the American Statistical Association*, Vol 28, 1943, pp 43-56.

¹⁸A. Deaton and J. Muellbauer, 'An almost ideal demand system', *American Economic Review*, Vol 88, No 3, 1980, pp 312-326.

¹⁹A.S. Deaton, J. Ruiz-Castillo and D. Thomas, 'The influence of household composition on household expenditure patterns: theory and Spanish evidence', *Journal of Political Economy*, Vol 97, No 1, 1989, pp 179-200; R.A. Pollak and T.J. Wales, 'Demographic variables in analysis', *Econometrica*, Vol 49, 1981, pp 1533-1551; R. Ray, 'The testing and estimation of complete demand systems on household budget surveys: an application of aids', *European Economic Review*, Vol 17, 1982, pp 349-369.

²⁰Refers to sorghum bread, which is the main food staple for the vast majority of the study households.

in Equation (1) above, namely: cereals,²⁰ animal products (milk, meat, eggs); fats, oils, sugar, tea and vegetables; all food; clothing and other personal items (soap, tobacco, alcoholic drinks, etc); and social and religious functions. Expenditure on durable consumption goods and human capital (education, health, marriage, etc) are treated as investment expenditures in this study. This classification of expenditure groups was chosen to distinguish food from others (cloth, etc) and to separate spending on food into basic foods (cereals, oils, sugar) and high-value nutrients such as animal protein.

Very little consumption of wheat was reported among surveyed farmers. The cereal item here therefore refers to sorghum bread, which is the main staple food for the Rahad farming community. While all farmers retained all or part of their sorghum production for household consumption, most of them sold surplus in the free market. This indicates that the Rahad tenants are fully integrated into the market economy and their decision to consume their own sorghum represents a rational economic choice given the market opportunities open to them. The proportion of sorghum retained or sold in the market is therefore determined according to farmers' expectations of future prices compared to current market prices and the opportunity cost of storing the produce for future consumption.

No selling of milk and very little meat purchasing was observed. The market for animal products was very small on the scheme and almost all farming households raised livestock and were nearly self-sufficient in animal products. All farmers also bought their oils from the market and none was observed to process groundnut oil at home. Food items consumed from own production, received as wages in kind and as gifts were included in the estimation of household expenditures using their imputed values.

The following regressors are contained in Z_j :

- initial wealth (W_0): the stock of physical and financial assets controlled by each of the farmers at the beginning of the year. As land is publicly owned and its use is equally allocated among tenant farmers, the wealth variable represents the value of the stock of production and work animals, the value of farm tools and implements, and non-farm income-generating assets (commercial capital);
- family size (N): the total number of adult-equivalent members of the family;
- dependency ratio (D): the proportion of children below 10 years and elderly family members (above 60 years of age);
- source-of-income ratio (R): the ratio of net farm returns to total disposable family income. A low value of R indicates multiple sources and hence stable income.

The source-of-income ratio is used to test Friedman's permanent income hypothesis (PIH). According to the PIH the marginal propensity to consume (MPC) out of permanent income is high while transitory income is almost completely saved. Large values of R indicate a high share of the unstable (transitory) component of income. Negative signs for R will therefore be consistent with the PIH. The wealth variable is used to explain the effects of social status on consumption patterns and to verify the entitlement approach to the problem of poverty and hunger.

Table 1. Estimates of the Engel share equations for the different commodity groups.

	Sorghum bread	Oils, tea and sugar	Animal products	All food	Cloth and personal items	Social and religious functions
Constant	0.67 (3.04) ^c	1.124 (4.19) ^c	-0.91 (-2.46) ^c	0.84 (4.97) ^c	0.243 (3.31) ^c	-0.083 (-0.53)
Total expenditures	-0.07 (-2.19) ^c	-0.105 (-2.83) ^b	0.171 (3.89) ^c	0.009 (0.39)	0.027 (2.7) ^b	0.019 (0.86)
Family size	0.012 (1.92) ^a	-0.011 (0.71)	-0.008 (1.87)	0.0013 (1.82) ^a	0.013 (2.74) ^b	-0.012 (-1.66) ^a
Dependency ratio	-0.007 (-0.86)	-0.004 (-0.92)	0.005 (1.16)	-0.009 (-0.65)	-0.0013 (-0.48)	0.0032 (1.99) ^a
Source of income	-0.003 (-0.53)	-0.006 (-1.8) ^a	0.005 (0.69)	-0.0033 (-1.42)	0.0003 (0.93)	0.003 (0.84)
Wealth	-0.002 (-0.98)	0.009 (2.013) ^a	0.004 (0.84)	-0.0024 (-1.76) ^a	0.0007 (1.52)	0.0031 (1.86) ^a
R ²	0.29	0.32	0.38	0.29	0.34	0.51
Durbin-Watson	1.99	2.07	1.75	2.02	2.03	1.85
Sample size ^d	94	94	94	94	94	94

^{a,b,c}Indicate significance at 10%, 5% and 1% levels, respectively. ^dSix observations were dropped for non-response in the consumption survey. Figures in brackets are t-statistics.

Data on the above variables as well as other socioeconomic attributes of the farming families in the Rahad scheme were collected from a sample of 100 households using frequent visit surveys during 1981-82. A multistage proportional stratified random sample was used to collect factual information from farmers. The stratification was based upon variation in locality (administrative division) reflecting variation in soil, proximity to markets and tribal origin. Selection of respondents was carried out in three stages starting with the random selection of blocks, followed by villages, to end up with the systematic selection of tenants. As stratification and random selection cater for statistical errors, memory bias was reduced by the frequent interviewing of the selected tenants. Each farmer was interviewed three times during the season. Visits were planned so that each followed the completion of a major sequence of farming operations.

The study did not survey landless farm workers, an important group of the rural poor in Sudan. Tenant farmers and their families, however, represent the main source of labour on the scheme in addition to the seasonal hiring of immigrant labourers during cotton picking. Resident landless workers and their families, on the other hand, constituted a very small proportion (less than 5%) of the population on the scheme. Each farmer cultivates a 22 feddan²¹ tenancy under scheme-mandated crop rotation, where cotton occupies half the land while sorghum and groundnuts share the other half. Cotton is delivered to the Rahad corporation, whereas sorghum and groundnuts are sold by the individual tenants to private buyers. A more detailed description of the study area is given elsewhere.²²

Results and analysis of household consumption patterns

Estimates of the parameters of the model are given in Table 1.²³ The sorghum bread and oils, tea and sugar groups represent inferior diets as households were observed to consume higher shares of animal products with higher total spending. The Engel assumption that food share (all food) in total spending declines with income did not hold for this population, however, since total expenditures have a positive, though not significant, effect on total food expenditure. In connection with this result, the significant negative effect of wealth on food's share could provide an explanation for the inconsistent sign of income effects on food demand. It indicates the importance of social status in explaining

²¹1 feddan = 0.41 ha.

²²Hassan, Fletcher and Ahmed, *op cit*, Ref 16.

²³An instrumental variable (IV) estimator is computed where current income is used as the IV to correct for the joint determination of X total expenditure and commodity spending X_i . No significant gain in efficiency of parameter estimation is realized with the IV procedure.

the nutritional intake behaviour of households. While the very poor households, being far below food saturation levels, increase the share of food purchases in their total spending, the rich, on the contrary, turn to buying higher shares of nutritive food and non-food items as income increases. This result implies that the food consumption behaviours of households at different positions on the social ladder are different. It further indicates that Engel's hypothesis of declining food shares is applicable only after some turning point when a minimum level of basic food needs is satisfied. Similar results have also been obtained elsewhere.²⁴

Family size increases the share of basic food (sorghum bread) while decreasing consumption of higher-value foods and social spending. As the family gets bigger more resources are devoted to buying basic food and clothing than other expenditures. The dependency ratio, on the other hand, works in the opposite direction. The fact that milk is the basic food for dependants in rural Sudan leads to the increase in the share of animal products as the dependency ratio rises. Moreover, spending on social ceremonies associated with having children (such as birth and circumcision) increases with the number of dependants.

The negative impact of source of income on food expenditure shares except animal products is in line with expectations. One of the most common forms of saving in rural Sudan, due to the absence of financial intermediaries and formal banking, is building up animal stocks. Since a large proportion of animal product consumption comes from own production and stock, a positive relation between consumption of animal products and transitory income (high *R*) can exist. Most of the estimated equations did not perform well, which is generally the case with cross-sectional data, especially when collected in a relatively homogeneous population in terms of geographical, technological and occupational variability.

Measuring food poverty

To measure the extent of relative poverty among the Rahad tenants, Gini concentration ratios were calculated in a previous study.²⁵ The results showed that the wealth gap between rich and poor farmers increased by 20% over the year of the investigation, in spite of the absence of unequal ownership of land as a source of inequality and social differentiation on the scheme. Unequal access to capital was found to strongly influence the distribution of family income and the saving and accumulation abilities of the tenant farmers.

An index of absolute food poverty is measured in this section for the same population of farmers. Two steps, identification and aggregation, are involved in constructing a poverty index.²⁶ Identification is the process of defining a minimum level of nutrition necessary to maintain healthy living – the 'poverty line' for the society under study, below which people are classified as poor subsisting on inadequate nutrition. Aggregation, on the other hand, derives poverty statistics for the society.

Several methods for establishing poverty lines are available in the literature.²⁷ The cost-of-calories (COC) method proposed by Greer and Thorbecke is used in this study for its simplicity and ease of computation.²⁸ In this procedure a COC function of the following form is to be estimated:

²⁴M. Lipton, *Poverty, Undernutrition, and Hunger*, Staff Working Paper 597, World Bank, Washington, DC, 1983; N. Edirisinghe, *The Food Stamp Scheme in Sri Lanka: Costs, Benefits, and Options for Modification*, International Food Policy Research Institute, Washington, DC, 1983.

²⁵Hassan, Fletcher and Ahmed, *op cit*, Ref 15.

²⁶Sen, *op cit*, Ref 6.

²⁷Fields, *op cit*, Ref 2; A.K. Sen, 'Poor, relatively speaking', *Oxford Economic Papers*, Vol 35, No 2, 1983, pp 153–169.

²⁸Greer and Thorbecke, *op cit*, Ref 4.

Table 2. Summary statistics and poverty measures among Rahad tenants.

Variable	Value
Cost-of-calories equation	Constant = -0.219 (-5.19) ^a Slope coefficient = 0.00005 (13.28) ^a R ² = 0.67
Recommended daily energy levels (L)	2000 Kcal
Poverty line (Z): 'cost of the minimum energy requirement per adult equivalent'	£0.89 per day £324.05 per year
Poverty measures	
Weighted shortfall index (P)	0.021 ^d
Head count (H)	0.34
Aggregate income gap (G)	-30.97

^{a,b,c}Indicate significance at 10%, 5% and 1% levels, respectively.

^dThe Engel elasticity of demand for calories is obtained from $\frac{1}{x} \frac{dx}{x_j}$ where \hat{b}_j is the OLS estimate of b in the equation ($\ln C = a + bx + u$). Figures in brackets denote t-statistics.

$$\ln x = a + bC \quad (2)$$

where x is food expenditure and C is calorie consumption. The calorie contents of the recommended daily nutrients level (L) are used to derive the poverty line Z :

$$Z = e^{(a + bL)} \quad (3)$$

Z gives the cost of buying the minimum calorie intake L . Note that the Engel elasticity of calorie demand (ϵ) is obtained by inverting Equation (2). A daily recommended level of energy intake of 2000 Kcal per adult equivalent is used to compute Z using the OLS estimates of a and b given in Table 2.²⁹ Based on Z several poverty measures are calculated. The weighted shortfall index P ³⁰ is given by:

$$P = \frac{1}{N} \sum_{j=1}^m (\epsilon_j G_j / Z)^2 \quad (4)$$

where $G_j = Z - X_j$ is the food expenditure deficiency, ϵ_j is the Engel elasticity of energy demand faced by individual j , N is total population and m is the number of poor.

The weighted shortfall index P measures at the aggregate level, for a given elasticity of demand for food, the extent to which poor households are below the food poverty line. When all the households are above the poverty line the weighted shortfall index takes the value zero. The extent to which the shortfall index value deviates from zero is a reflection of the poverty situation in a society. In implementing poverty alleviation policies and programmes the values of the index could be monitored over time and compared among the different groups of the population. The poverty index P satisfies the monotonicity and transfer axioms for an aggregate poverty measure whereas the aggregate income gap (G) and the head count ratio (H) measures pass only the monotonicity condition.³¹ H and G are obtained as follows:

$$H = \frac{m}{N} \quad (5)$$

$$G = \sum_{j=1}^m G_j \quad (6)$$

²⁹Calculated from survey data based on FAO, *Food Consumption Tables for the Near East*, Food and Nutrition Paper No 20, FAO, Rome, 1982.

³⁰Greer and Thorbecke, *op cit*, Ref 4.

³¹Sen, *op cit*, Ref 6.

Table 2 presents the summary statistics and poverty measures for the Rahad tenants. The cost-of-calorie equation had a significant slope coefficient and reasonable explanatory power. Based on the recommended daily energy levels (L) of 2000 Kcal the poverty line (Z) for the study households is found to be £0.89 per day and £324.05 per year

per adult equivalent. During the period of the study (1981–82) the average per capita income for Sudan was S£300, which is an indication that the poverty line derived is a conservative one. This is, of course, due to the fact that the sample under analysis did not include landless farm labourers and the urban poor.

Poverty measures derived on the basis of this poverty line in Table 2 indicate that 34% of the sample households are poor by head count (H); the weighted shortfall index (P) is 0.021 and the aggregate income gap (G) is -30.97. These figures compare favourably with measures of poverty for rural Kenya.³² This is mainly due to the relatively favourable status of rural households on the Rahad scheme compared to smallholder farming families in the Kenya study. Also, Rahad tenants had much better access to institutional services than most rural households in Sudan, especially in the traditional rainfed sector of the country. Schools, dispensaries, feeder roads, institutional credit, etc, though far from adequate, are provided as part of the scheme set-up, whereas such facilities are lacking in most of rural Sudan. The poverty indices generated in this study are therefore considered to underestimate the extent of rural poverty in Sudan. They provide useful measures, however, to compare with poverty indices elsewhere in Sudan and assess the impact of integrated rural development projects such as the Rahad scheme on food poverty.

Determinants of food poverty

The relationship between rural poverty and various economic and social variables has been examined in a number of studies. All-country, as well as state, village and household-level data have been utilized in these studies to explain poverty. Most studies have employed descriptive techniques and have focused on the effects of movements in aggregate forces such as agricultural productivity and cost-of-living indices.³³ Analytical methods, however, were employed in a limited number of studies to measure the influence of aggregate factors as well as micro-level attributes of households on the distribution of rural poverty³⁴ and nutrients intake.³⁵ An econometric analysis of the determinants of food poverty in the Rahad scheme is given in this section. The logit model is employed to explain the probability of being poor for Rahad tenants.

Farming families are classified into poor and non-poor using the poverty line measure (Z) derived in the preceding section. The probability that a household cannot afford a nutritionally adequate diet is conditional on several factors. The logit model measures the parameters of the conditional probability of poverty assuming a non-normal distribution of the chance of being poor. The relationship between the binary status variable (S_i) and its determinants (Q_i) is specified as:

$$\begin{aligned} S_i &= \beta'Q_i + v_i \\ S_i &= 1 \text{ for } x_i \leq Z, i = 1, \dots, N \\ &= 0 \text{ otherwise} \end{aligned} \quad (7)$$

Q_i is a vector of explanatory variables and β is the vector of respective parameters. The logit procedure computes a maximum likelihood estimator (MLE) of β given the non-linear probability distribution of the random error v .

³²Greer and Thorbecke, *op cit*, Ref 4.

³³A.R. Khan and K. Griffin, *Poverty and Landless in Rural Asia*, ILO, Geneva, 1982; Ahluwalia, *op cit*, Ref 12; A. Saith, 'Production, prices, and poverty in India', *Journal of Development Studies*, Vol 17, No 2, 1981, pp 178–192.

³⁴Bardhan, *op cit*, Ref 13; Gaiha, *op cit*, Ref 13.

³⁵Heien, Jarvis and Perali, *op cit*, Ref 12.

Table 3. The logit parameters of the probability of being poor.

Variable name	Parameter value	t-ratio
Constant	-8.62	-3.64 ^a
Family size	8.34	4.42 ^a
Dependency ratio	-0.21	1.05
Source of income	0.22	1.68 ^a
Wealth	-0.38	-1.82 ^a
Farming experience	-0.16	-1.34
Chow R-square	0.617	
Durbin-Watson	1.84	
Sample size	94	

^{a,b,c}Indicate statistical significance at 10%, 5%, and 1% levels, respectively.

No time series data on poverty variables were available for the population under study to allow for the use of productivity growth or cost-of-living indices. On the other hand, technology variables are fixed across the scheme as levels of chemical inputs and mechanization applied are determined by the Rahad Corporation. The absence of effective variation in technology plus the fact that all tenants have equal access to land led to the search for other factors to explain the observed variations in standard of living on the scheme. It has been found in a previous study that unequal access to capital measured as the level of initial wealth (w_0) significantly influences the distribution of current family income and the consumption and savings abilities of Rahad tenants.³⁶ This result is further confirmed by the results presented earlier. Wealth (w_0) is therefore used in the present study to examine the effect of access to assets other than land on poverty. A variation in the timing and frequency of irrigations between tenants has been observed in the public irrigation schemes of Sudan. This implies unequal access to irrigation water. The effect of this factor on yields and incomes has been measured in a number of studies³⁷ using the location of tenancy on the irrigation canal as an index of access to water in the Gezira and Manegil schemes. No such data were available from this survey to allow for studying the effect of unequal access to water in the Rahad scheme.

Two household characteristics are also used as explanatory variables. The size of the family (N) and the ratio of non-earning dependants (D) are expected to increase the probability of poverty. The source-of-income ratio (R) is also used as a regressor to reflect the effects of participation in non-farm as well as off-farm activities such as trade, wage labour and other income-generating functions. Higher values of R indicate lower participation and hence are expected to increase the probability of being poor. The years of farming experience of the head of household was also used to explain the chance of getting poor. Experienced farmers are expected to be good managers and thus efficient users of farm resources and earners of better incomes.³⁸

Estimates of the logit model parameters are given in Table 3. All variables except dependency ratio have the right signs and are statistically significant. The larger the size of the household and the lower the share of non-farm earnings (high R) the higher the probability of absolute poverty for the family. Better access to productive assets and longer farming experience, on the other hand, reduce the chance of falling below the poverty line. The negative effect of higher dependency ratio can be explained by the inverse relationship between the number of dependants and number of adult-equivalent members on which nutritional needs are calculated. The larger the number of active adults

³⁶Hassan, Fletcher and Ahmed, *op cit*, Ref 16.

³⁷H. Faki, A. El-Badawi and C. Baily, 'The effect of farm location on cotton yields and farm incomes in the Gezira scheme', in O. Fadl and C. Baily, eds, *Water Distribution in Sudanese Agriculture*, University of Gezira, Sudan, 1984; H. Faki and M. Ismail, 'Impact of wheat technology transfer in Gezira scheme', in *Proceedings of the Annual National Wheat Coordination Meeting*, ICARDA Nile Valley Project, Agricultural Research Corporation, Sudan, 1989.

³⁸The inclusion of farmers' farming experience as one of the explanatory variables in the model was suggested by one of the referees.

Table 4. Effects of selected household characteristics on food intake and poverty in Rahad scheme (sign effects).

	Intake of basic food (sorghum)	Intake of nutritive foods	Total intake of food	Probability of being poor
Income/total expenditure	-	+	(+)	NA
Wealth (<i>W</i>)	-	+	-	-
Family size (<i>N</i>)	+	-	+	+
Dependency ratio (<i>D</i>)	-	+	-	(-)
Source of income (<i>R</i>)	-	+	-	+
Farming experience	NA	NA	NA	-

Notes: Bracketed signs indicate inconsistency with expectations. NA = not available.

the higher the cost of minimum nutrition and thus the higher probability of poverty.

Table 4 summarizes results of the Engel curve and logit analyses. The table indicates the direction of the relationship between household characteristics and the amount and composition of food intake and poverty in the Rahad scheme. It is clear that for Rahad tenants to shift from basic staple to high-nutritive foods they need to earn higher incomes, build up assets (accumulate wealth), maintain smaller families and diversify their income-generating activities (high *R*). Better access to productive assets, smaller family size and increased earning from sources other than farming will also lead to lower proportional spending on food and improve non-food spending and the saving capacity of farmers. Good family planning and provision of increased farm and non-farm employment and income opportunities along with better access to capital and other productive assets will therefore contribute to better nutrition and a higher capacity for asset accumulation among Rahad tenants.

Table 4 also shows that in order to reduce nutritional poverty in the Rahad better knowledge of farming practices, higher shares of income-generating activities other than farming, larger stocks of assets and smaller families are required. Consequently, policies directed towards improved access to services such as family planning, education and agricultural extension and increased market opportunities for the Rahad tenants will be expected to reduce absolute poverty on the scheme. Better market accessibility and increased labour mobility for more effective utilization of the family's idle time between seasons can be enhanced through improved infrastructure. Promotion of local post-harvest processing industries and integration of livestock production, processing and marketing into the existing farming system will also lead to more efficient utilization of farm resources and higher employment and income levels, hence reduced nutritional poverty.

The fact that the Rahad tenants have better access to institutional services such as schools, extension, roads and markets than other rural populations in Sudan indicates the severity of rural poverty among farmers where these services are lacking, such as the rainfed smallholder sector of Sudanese agriculture. However, these facilities are far from adequate in the Rahad scheme and hence programmes that would improve access to such services in Rahad or elsewhere in the country should be implemented in order to promote better nutritional status and lower poverty among the rural families of Sudan.

Summary and conclusions

With increased poverty levels within developing countries, and particu-

larly the recent severe food crisis in Africa, development planning has had to change towards poverty-focused strategies. Policies and programmes that reduce relative and absolute inequalities in the distribution of the benefits of economic growth have to be designed and incorporated. Adequate investigation into the nature and determinants of the process of poverty is therefore essential for effective development planning. An attempt was made in this study to contribute to this task. The severity of poverty among the rural population of irrigated Sudanese agriculture was measured using recently developed indices. Determinants of household consumption patterns and food poverty among tenant farmers of the Rahad irrigation scheme were then analysed.

Regression procedures were used to estimate Engel curve parameters for several commodity groups. Wealth, family size, dependency ratio and a source-of-income ratio were used to explain the composition of household consumption. The results indicate that Engel's hypothesis of declining food shares is irrelevant for poor households who are far below a minimum level of basic food satisfaction. The permanent income hypothesis, on the other hand, was supported. Wealth and source of income therefore proved to be important in explaining the demand behaviour of farming households in Sudan.

The poverty line is estimated to be S£324 per year, which buys the recommended daily energy intake of 2000 Kcal per day per adult. This was higher than the average per capita income for the country, which was S£300 for the study period. This indicates that the number of poor in Sudan will be found to be higher than the 34% rate estimated for the Rahad tenants when the relatively disadvantaged small farmers of the remote rainfed sector, landless farm workers and the urban poor are added to the sample. The weighted shortfall index was estimated to be 0.021, which ranks much lower than the Kenyan index for small farmers.³⁹

A logit analysis was conducted to explain the incidence of poverty among the Rahad tenants. The results provided further support to previous empirical evidence for the strong positive effect of large family size and low participation in off-farm activities on the probability of falling below the poverty line. The study also confirmed the negative relationship between access to productive assets and the chance of getting poor. Farming experience was found to reduce the chance of not having adequate food and thereby falling below the minimum calorie intake. Thus, given the nature of the sample households analysed, the study results indicate that assuring equal distribution of land and water through land reforms and irrigation schemes does not guarantee improved standards of living if not supported by proper poverty-based socioeconomic policies and an appropriate institutional environment. Policies directed towards the provision of better family planning, education, extension and other social services as well as better access to institutional credit and other productive assets and increased farm and non-farm employment opportunities for farmers are important for reducing food poverty in the Rahad.

³⁹Greer and Thorbecke, *op cit*, Ref 4.