THE FOOD ACCOUNTING MATRIX: AN ANALYTICAL DEVICE FOR FOOD PLANNERS*

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INTRODUCTION

This paper represents a preliminary report of a method of handling food data which was devised on the basis of the author's experience in Africa during a period of acute food shortage.[1] The usefulness of the method is not confined to famine but may also be applied to other planning problems which arise during the course of agricultural development. The method sets conventional food commodity data in physical units in the framework of an accounting matrix in order to document the flows between various groups of producers, enterprises, institutions and consumers, and also, in the same framework, the distribution of commodities within these groups. Essentially, the method is a simplified version of social accounting applied to food commodity accounts in a highly disaggregated form. It lacks the complexity (but also the breadth) of other methods with which it is related, such as the Social Accounting Matrix.[2] On the other hand, it may be used in association with the SAM or embedded in a full scale economic model. It may be applied at a country, region, area, village or project level, and the 'level of focus' may be adjusted to serve different purposes. It shows explicitly the relationship between self-provisioning and monetized modes of household food acquisition. The design of a matrix for a particular area shows the structures which influence food commodity flows. In itself it lacks technical content but may be used with technical relationships to examine the effects of environmental change or the way a particular government policy is likely to influence food availability to a particular group of households.

The foremost condition in mind in devising this technique was that it should preserve the disaggregated nature of data generated by conventional surveys in order to show 'who has what'. Different groups of households which provide final demand for food remain identifiably separate, and complete flexibility is available as to how these households are classified. However, the method has certain implications for survey design which are discussed later.

The method has three main types of uses. In its simplest form it may just provide a framework for presenting current data in a disaggregated form in order

* The author is grateful to Professor J. A. C. Brown of the Institute of Economics and Statistics for helpful advice and criticism, to Roger Freeman of the Food Supply Analysis Group for assistance with the design and production of the diagrams and to Mrs Sheila Carmichael for typing the manuscript.

The work of the Food Supply Analysis Group is supported by a grant from the Economic and Social Committee for Overseas Research of the Overseas Development Administration, Foreign and Commonwealth Office, U.K.

The views expressed here are those of the author and not necessarily of either his advisors or the Overseas Development Administration.

[1] For a non-technical discussion of the analytical problems see: Hay (1978).

[2] The literature on accounting matrices is now extensive; see for example: United Nations (1968); United Nations (1975). In particular for applications of the Social Accounting Matrix to development planning see: Pyatt and Round (1977).

to show the pattern of food flows from production to consumption. Over time, changes in food commodity flows may be plotted and compared with the 'requirements' of groups vulnerable to shortage. The method is therefore particularly suitable for analysing data from 'food supply monitoring' systems.

Secondly, the matrix may be used to forecast the 'one step ahead' effects of changes in domestic output. The effects of drought have received most attention so far. Used in this way it becomes a tool for famine warning although, as it stands, it is a crude device because within-group transfers tend to occur before and during serious food shortages, and this adds to the problems of predicting how many people will require external assistance.[3]

In common with input–output methods and other accounting matrices, the use of fixed coefficient matrices to provide new solutions for changed conditions implies proportionate changes within the matrix. This constraint may be relaxed if behavioural relationships are used to predict change; the matrix then simply ensures consistency between aggregate production and consumption, given that accumulation may occur.

Thirdly, it may be used to simulate the effects of policy or direct intervention and may, therefore, provide the basis for a simple policy laboratory. In contrast with more recent versions of the Social Accounting Matrix,[4] the Food Accounting Matrix may be more useful if the dependent variables of models held exogenous to the matrix are used to provide data for specific cells during modelling experiments. The method allows the precise specification of objectives, instruments and constraints for modelling the likely consequences of policy change but because the method itself does not imply particular technical assumptions, the user may choose his own models to simulate the response from producers and consumers in his area.

The first part of this paper presents a summary of the procedures required to set up a Food Accounting Matrix. In the second part the problems associated with documenting the inequalities within groups of households are discussed. Finally, some applications of the method are illustrated by example.

Structure and Design

The Structure of the Food Accounting Matrix

The Food Accounting Matrix (FAM) is a matrix of commodity flows usually expressed in physical units per time period. In common with other accounting matrices[5] it is square being composed of row-column pairs representing accounts allocated to groups of producers, enterprises and consumers. The total of the elements of each row is equal to the total of the elements of the corresponding column. Following the usual convention, inflows (or receipts) to each account are entered in a row, and outflows (or disposals) in the corresponding column. Thus, each filled cell of the matrix represents the amounts of commodities which flow out of one account into another during a specified 'accounting period'.

[3] Hay, R. W., *et al* (in preparation).
[4] See for example: Pyatt and Roe (1977).
[5] See: United Nations (1975) *op cit.*

The Food Accounting Matrix is divided into four parts (Fig. 1: i–iv). The left-hand upper corner of the matrix (i) shows net domestic production by commodity, by group of producers and its disposal to seed, sales, own consumption and losses. The distinction between gross and net production may be trivial but is important for the design of the matrix. For the purpose in hand gross output means production of the standing crop as measured in the field. Net production on the other hand is production available for disposal and includes post-harvest losses. This distinction allows net production to be shown by group of producer (see Fig. 2 for example) in the rows of a sub-matrix where the columns show production by commodity. The total of these columns including production losses gives gross production by commodity. These totals are used later as a device to 'close' the matrix. The centre of the matrix (ii) shows flows between institutions which provide intermediate demand, such as the State, food processing industries, and the rest of the world. (iii). Row-column pairs which border the centre of the matrix below and to the right are allocated to households which consume food. Receipts

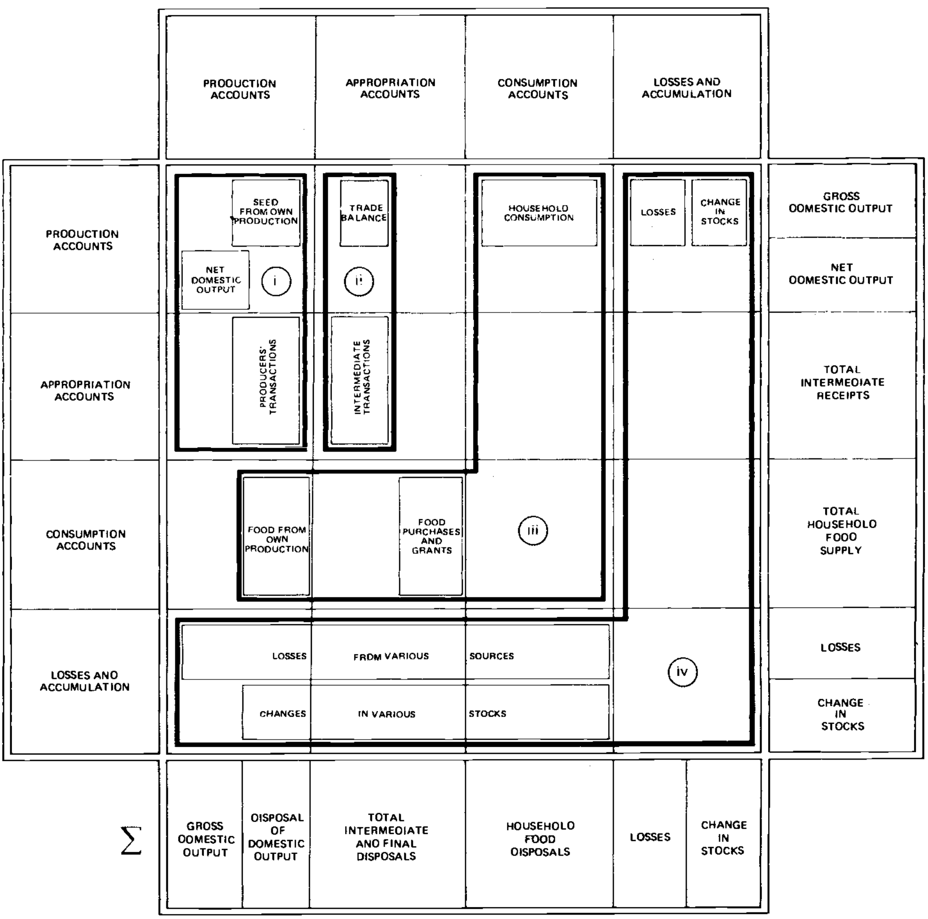


Fig. 1A. The basic design of a Food Accounting Matrix.

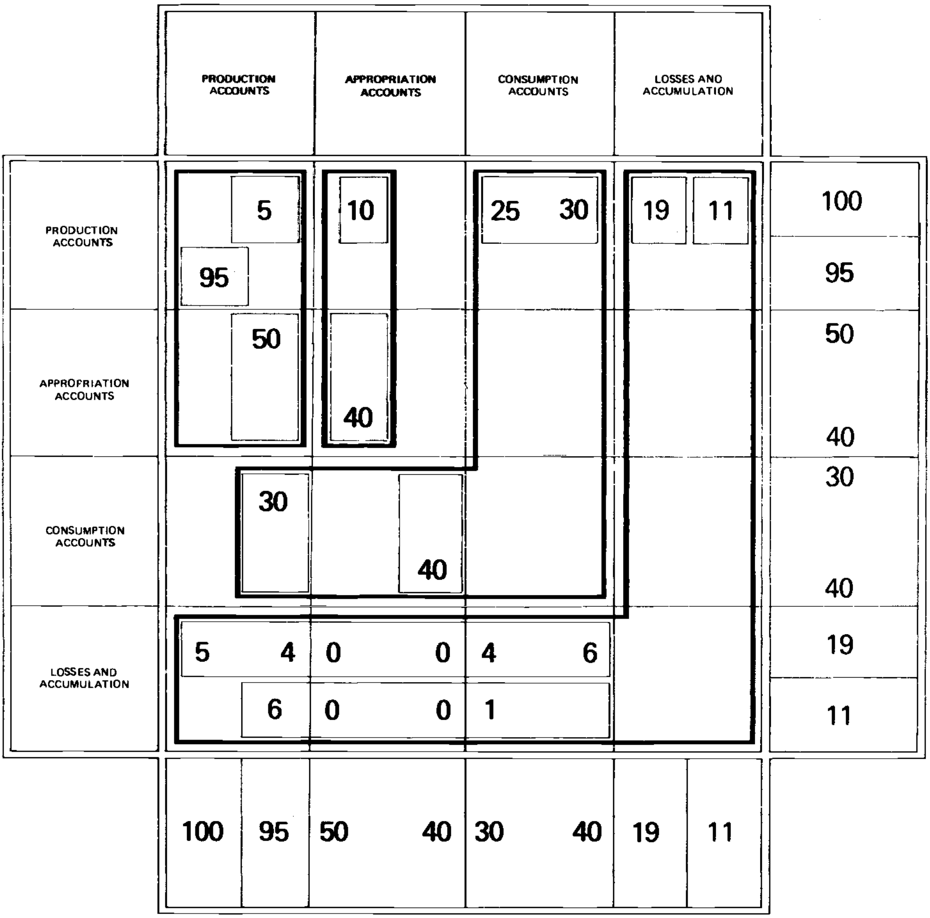


Fig. 1B. The basic design of a Food Accounting Matrix.

Notes: To preserve the flow identities implied, the total of each row must be numerically equal to the total of the corresponding column:
e.g. TOTAL INTERMEDIATE RECEIPTS = TOTAL INTERMEDIATE AND FINAL DISPOSALS.
The numerical example (Fig. 1B) shows flows of one commodity from one group of producers to two groups of consumers.
Accounts are superimposed on the basic structure shown in Fig. 1A.

by households from their own production, the market, or as grants are shown in the rows, and actual consumption in the corresponding columns. Accounts bordering the bottom and right-hand edge of the matrix (iv) are used to show losses from all accounts and changes in stock in a way analogous to the 'accumulation' accounts of value matrices.

The Matrix is 'closed' by utilizing the identity between final domestic consumption, trade balance with the Rest of the World, losses and net changes in domextic stock, and gross domestic production. Flows to the Rest of the World, final consumption, total losses and net change in domestic stocks are shown as commodity vectors across the top border of the matrix. In contrast to the Social Accounting Matrix which shows money flows, the FAM shows the physical flows of commodities. Thus, for example, 'exports' are flows out of the country to the Rest of the World, and a positive trade balance signifies additional drawings on the country's domestic output. These terms may therefore be regarded as outflow terms reversing the row/inflow column/outflow rule. The elements of the corresponding group of columns also sum to gross domestic production. These row-column pairs are not allocated to any particular institution, but simply represent the terms of an aggregate 'food balance sheet'. The rest of the matrix shows how the aggregate balance between food production and final disposals is made up of contributions from different groups of producers and demands by different groups of consumers.

Group of accounts in the matrix may be designated production, appropriation, consumption and accumulation as shown in Fig. 1. The matrix may also be bordered with accounts showing actual stocks but this feature will not be discussed here.

FAM Design and Commodity Flow Analysis

The FAM may be used as a descriptive device for summarizing food commodity flow patterns. Endless variations may be played on its basic structure in order to display the contribution of various groups of producers, the role of the State, trade and commercial enterprises and thus, the sources of food for various groups of households. Indeed, the design of a Food Accounting Matrix is itself a way of analysing the pattern of food commodity flows in a country, as it offers an opportunity to identify, in sequence, factors which determine or modify the amount of food available to a group of particular consumers.

If production and consumption accounts are allocated to regions, spatial flows may be represented. Features of special interest, such as an agricultural development project or an area particularly prone to shortage, may be allocated accounts in order to show their position in, or contribution to, the general pattern of food supply or demand. Resettlement areas, famine prone areas, and in China, particular communes have been treated in this way.

The most interesting uses of a FAM require that its cells be filled with real data. However, a FAM designed to reflect the productive, social and economic structures of an area may be used as a systematic guide to the types of data which should be collected in order to estimate commodity flows from different groups of producers, through various institutions which handle food to different groups of consumers. Its design is, therefore, a useful preparatory exercise before the design of surveys. More commonly, however, the problem is one of 'missing data'. While this is always less than ideal, the consistent structure of the matrix means that the total of each set of inflow entries must be matched by a numerically equal total for the outflow entries. This constraint may sometimes be used to estimate data which are not available, to check the consistency of data coming from more than one source, or to insert 'best guesses' *in lieu* of missing data.

An accounting matrix such as this provides a framework for handling data from a number of sources so that the details of production or consumption for one group of households can be examined within the context of more general commodity flow patterns. The strength of the method depends to a great extent on the way accounts are allocated.

The Classification of Production and Consumption Units and the Allocation of Accounts

Various systems of classification have been advanced; any may be used as a basis for grouping holdings and households in order to construct an array of production and consumption accounts. On occasions it may be desirable to examine flow patterns in more than one way. Alternative arrays may be set up and used for different purposes. The discussion which follows should therefore be interpreted as illustrating the flexibility rather than the rigidity of the system.

(*i*) *Production Accounts*

(*a*) *Commodities and Units*

The first group of rows and columns is devoted to a vector of commodities which is then used consistently throughout the matrix. Various commodity classifications exist and have their uses. Most nutritional classifications are elaborations of a 'cereals, pulses, oilseeds, meat, dairy products, fish and fruit and vegetables' type of classification which would give a seven element vector if used without further disaggregation. However, the flows of a particular commodity or group of commodities might be examined in greater detail by expanding one part of the vector, and if necessary, collapsing the other parts of it into single elements to economize on space. The application of theories of producer and consumer behaviour may make other commodity groupings more useful.[6]

In its basic form the data in a FAM will comprise vectors and sub-matrices of quantities of commodities expressed in suitable physical units. However, a quantity vector may be transformed into a costs or price vector, a vector of values, or collapsed into a scalar representing total value or total quantity. Alternatively, a vector of commodity quantities may be transformed into a vector of nutrient values (energy, protein etc.). These alternatives give different meanings to the matrix and are useful for different purposes.

(*b*) *Productive Institutions*

The use of the word 'institution' here refers to any group of productive units. These might be land holdings, herds or fishing boats. The allocation of these accounts should reflect attributes which distinguish between types of producers or patterns in the disposal of production. The most obvious and usual distinction is drawn between large commercial farms and small holdings. However, the latter may be sub-classified by tenurial or userford types, by pattern of production, by level or type of technology etc. Alternatively, or in addition, productive

[6] The problem of commodity aggregation with respect to consumer behaviour is reviewed in Brown and Deaton (1973).

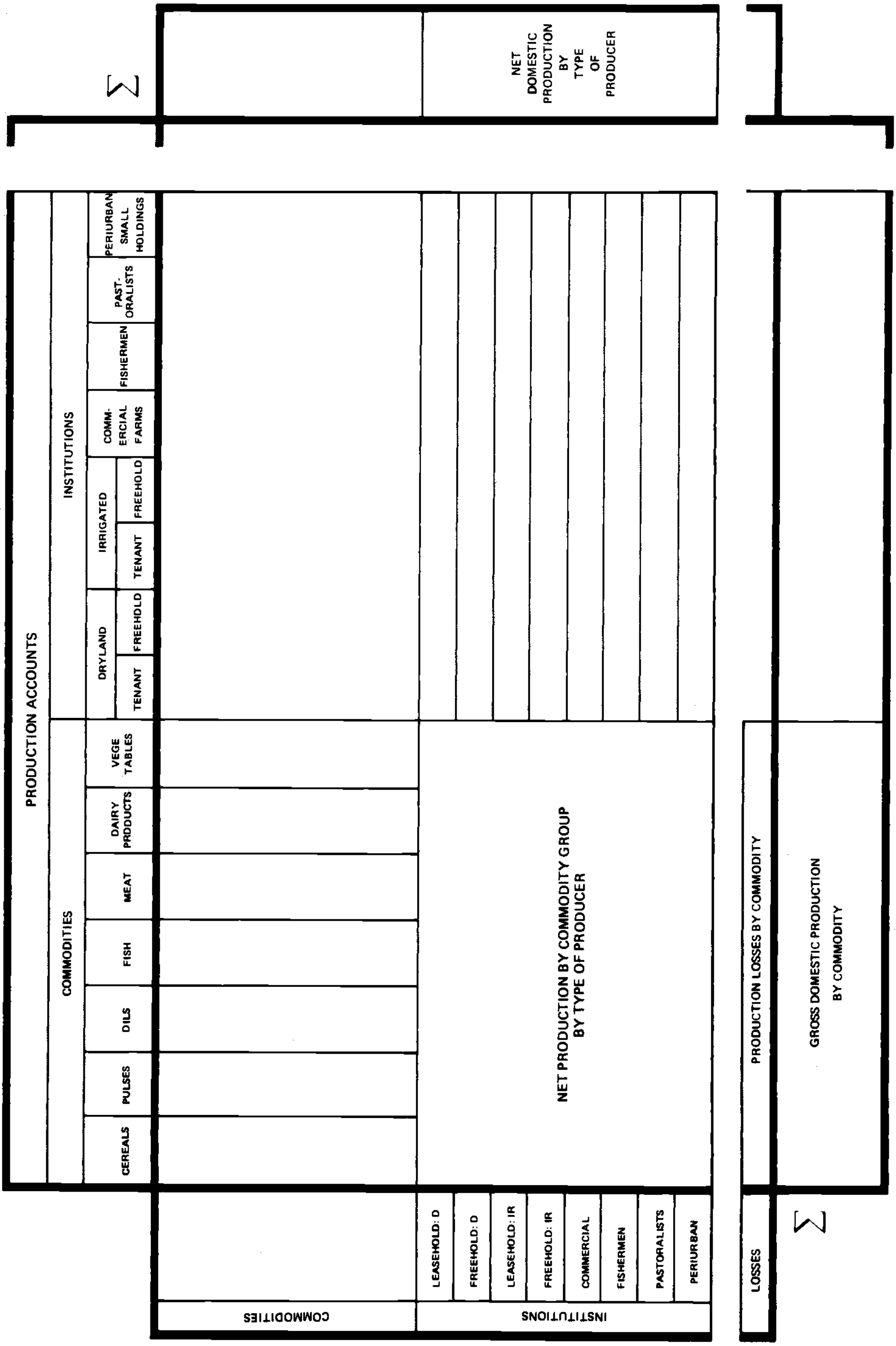


Fig. 2. Example of production sub-matrix.

'institutions' may be defined by the spatial location of holdings, in terms of administrative or ecological area or both, and an account assigned to each area.

In many third world countries commodity liabilities to landlords, partners, sharecroppers, workers and the government determine how much of his output a farmer is free to allocate to sales and own-consumption. In deciding how production accounts should be allocated the pattern of these liabilities may be as important as the nature of productive structures. The problem associated with the allocation of accounts is closely related to the problem of stratifying a survey sample. Indeed, because sample surveys are the usual source of estimates of production the precision of these estimates almost always dictates the limit of disaggregation of accounts.

The design of this part of the matrix will yield a sub-matrix of production net of field losses by institutions in the rows, and commodities in the columns (Fig. 2). Production losses by commodity are shown as a row vector in the losses account unless a breakdown by institutions is required, in which case the losses account can be expanded to form a sub-matrix showing institutions in the rows and commodities in the columns. Thus, the total of each column is equivalent to the gross output of each commodity.

The production accounts intersect the appropriation accounts where outflows from productive institutions (columns) cross the row accounts of institutions which appropriate the commodities. This produces a second sub-matrix showing the disposal of production by institution in the columns and receipts by appropriating institutions in the rows. The amounts consumed by the producer and his family are shown where the production accounts intersect the consumption accounts. Thus, the ways in which different groups of producers dispose of their production may be seen by reading down the 'production-institutions' columns. The totals of the elements of these columns disaggregated by commodities are equal to output, net of production losses, as are the totals of the corresponding rows.

(ii) Appropriation Accounts

This part of the matrix is designed to show intermediate flows between production and final consumption. Accounts are therefore allocated to institutions and enterprises which control or modify the flow of commodities to groups of households. A good design will make allowance for the actual or intended results of government intervention as well as showing the structure of the private sector. Accounts in this part of the matrix are also allocated to the 'Rest of the World', or in a matrix designed for one region only, to the 'Rest of the Country'.

In general, there are three features to be considered. The first concerns transfers not associated with money transactions, such as between producers and the government as commodity tax, or landowners as commodity rent, or grants given to households. Between household transfers are handled separately within the consumption accounts. The second group of accounts represents structures which influence price formation. It is mandatory to allocate at least one account to the 'the market' in order to gather together sales from various groups of producers. It is more helpful to border the appropriation sub-matrix with two row-column pairs, one allocated to primary transactions and the other to final transactions. However, further disaggregation may be required to show intermediate transactions where price is affected by the profits of middlemen, by transport costs or, as a special category, by manufacturing processes. Inflows to food processing industries are represented by a vector of raw commodity equivalents with processing losses added to the losses account.

The third group of appropriation accounts are allocated to institutions which are involved in commodity movements with the Rest of the World. The most obvious divisions of these accounts is between trade and aid and, within the trading allocation, between government and private enterprises. In some cases where imports make an important contribution to food supply, it may be helpful to disaggregate the accounts by port of entry so that port capacity can be taken into account during a planning exercise. Aid accounts may also be disaggregated to distinguish flows destined to, or arising from, different donor agencies or to be delivered to households under different conditions, for example as food grants or as 'food for work'.

Two examples of the arrangement of appropriation accounts are shown in Fig. 3 implying quite different structures, interests and problems. Row totals correspond to receipts by appropriating institutions; column totals correspond to total disposals including storage and other losses and any changes in stocks.

(iii) Consumption Accounts

Consumption accounts are allocated to households grouped by distinguishing characteristics and show, in the rows, the amount obtained by each group by source—for example, from own production, as wages, as grants, and from the market. The columns show its disposal to actual consumption to within household losses and waste, and to 'change in household stocks'. This latter is extremely difficult to estimate and may be that component of the matrix which most limits its accuracy in practice.

The classification of households as consumption units has received a great deal of attention during the design of household budget studies. In general, attributes expressing the way households obtain their food and pattern of food consumption are used to group households. These in turn determine the allocation of consumption accounts. For rural households an occupational classification such as cropping, herding, fishing and non-farm employment (i.e. pure market dependence) may be used. Households which produce food for their own consumption also appear as members of productive institutions in the production accounts of the matrix. A common classification is desirable but this will depend on the relationship between the household and its holding as a production unit and the household as a unit of consumption.

The classification of urban households is more complex. Classification by level of income has often been used as has occupation, ethnic group and socio-economic class. Each of these may have their uses. The classification of production and consumption units will be considered again at the end of the next section.

The sub-matrix representing actual consumption appears in the top right-hand

A		PRODUCTION ACCOUNTS (DISPOSALS)	APPROPRIATION ACCOUNTS								Σ
			LANDLORDS	TRADERS	GOVERNMENT	AID AGENCIES	RoW	AID ACTIVITIES: GRANTS	AID ACTIVITIES: FOOD FOR WORK	FINAL TRANSACTIONS	
		b	c	d	e	f	g	h	j	k	
COMMODITIES	A						EXPORTS MINUS IMPORTS				
LANDLORDS	C	COMMODITY RENT									LANDLORDS' TOTAL
TRADERS	D	PRODUCERS' SALES	LANDLORD'S SALES								TRADERS' TOTAL
GOVERNMENT	E	COMMODITY TAX		COMMODITY TAX		AID TO GOVT.	GOVT. IMPORTS				GOVT. TOTAL
AID AGENCIES	F						AID IMPORTS				AID TOTAL
RoW	G			COMMERCIAL EXPORTS	GOVT. EXPORTS						EXPORTS
AID GRANTS	H				GRANT ALLOCATIONS	GRANT ALLOCATIONS					GRANT TOTAL
FOOD FOR WORK	J				FOOD FOR WK. ALLOCATIONS	FOOD FOR WK' ALLOCATIONS					FOOD FOR WORK TOTAL
FINAL TRANSACTIONS	K			TRADERS TO RETAILERS	GOVT. TO RETAILERS						RETAILERS' TOTAL
HOUSEHOLD RECEIPTS	L	SELF-PRODUCED FOOD	RECEIPT OF FOOD AS WAGES					FOOD GRANT RECEIPTS	FOOD FOR WK. RECEIPTS	FOOD PURCHASED	HOUSEHOLD TOTAL
Σ		NET OUTPUT	LANDLORDS' TOTAL	TRADERS' TOTAL	GOVT. TOTAL	AID TOTAL	EXPORTS	GRANT TOTAL	FOOD FOR WORK TOTAL	RETAILERS' TOTAL	

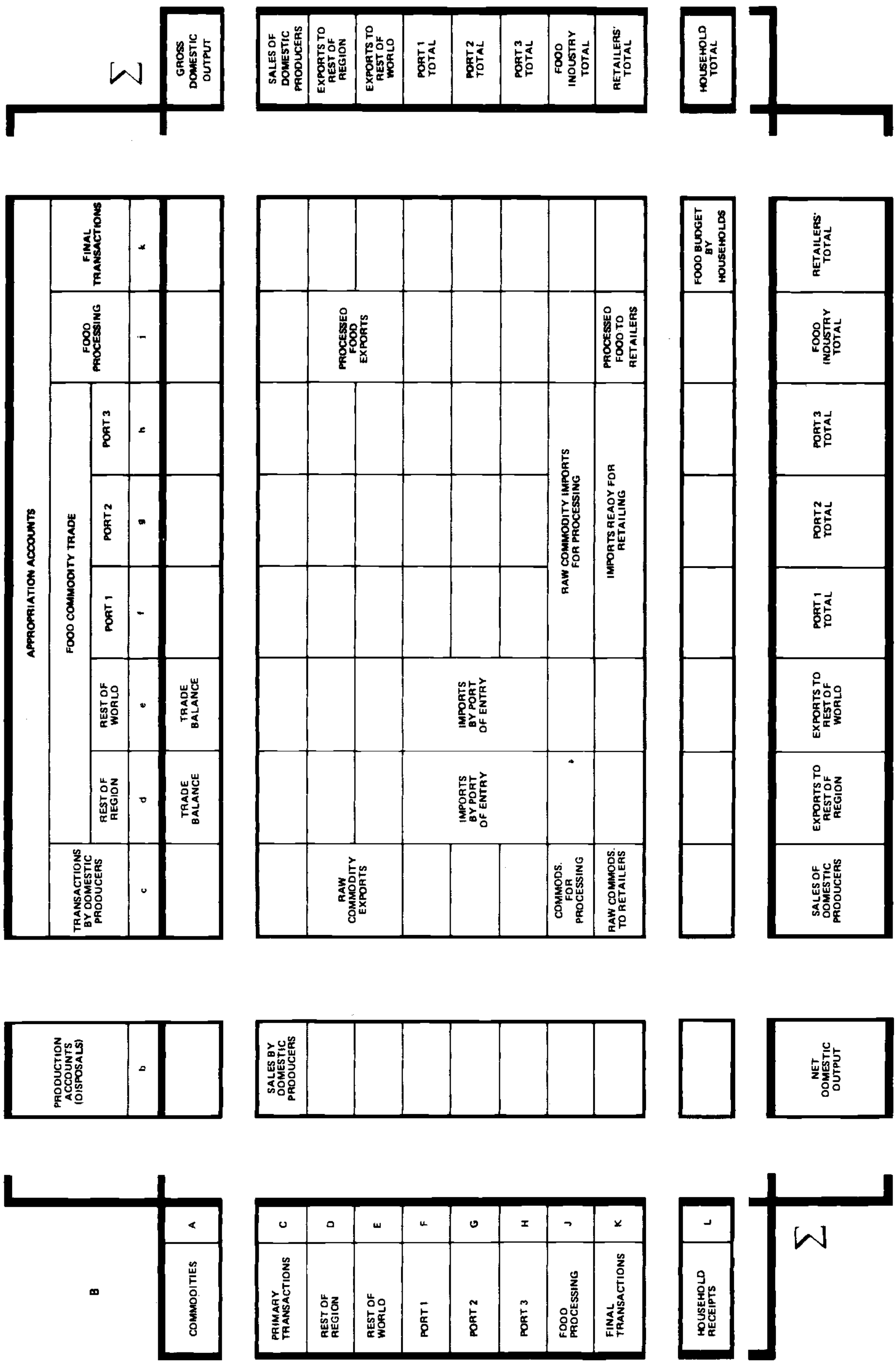


Fig. 3. Two examples of the appropriation sub-matrix.

corner of the FAM (Fig. 1A) showing consumption by commodity in the rows and by household group in the columns. An example is shown in Fig. 4.

As described so far, the design of the matrix allows the flows of commodities to be plotted from the point of production through various intermediaries to the point of consumption. Although transfers between accounts (groups) can, in theory at least, be captured in this way, the distribution of production and consumption within accounts has not been mentioned. This will now be discussed.

The Distribution of Food Commodities Within Groups of Households

The distribution of food within a group of households shows many of the features of the distribution of income with which it is often associated in monetized societies. If the total amount of food available to each group of households is divided by the number of households in the group, the average quantity available per household can be used to compare one group with another and this general level of food supply with some predetermined (but often debated) level of requirements. These comparisons are made more valid and vivid if households have been classified by some attribute thought to be related to nutritional well-being such as level of income or level of education. However, this assumes that all households in each group have access to the same share of what is available to the group as a whole.

Instead of this, the distribution of the available food amongst households in each group might be treated in ways usually used for analysing the distribution of income. For example, attempts could be made to fit any one of the distribution functions used in income distribution analysis to household food supply data. Or, a conventional measure of income inequality might be adapted to indicate relative food deprivation within each group of households.

In the case of food we are interested both in how much food each household commands and also in the relative levels of food supply between households. It is therefore important to know in absolute terms both how much food is available to the group as a whole and how it is distributed within a group. More interesting still is how a particular strategy either for growth or distribution will affect the amount of food available to each group defined in the matrix and to households within each group. This being the case, the real problem is to identify the processes which result in additional food becoming available to a group and whether or not they will favour those who need it most.

The following method of presenting the distribution profile of food supply for a given group of households is being explored. It resembles a Pen diagram of income[7] which ranks the recipients of income according to increasing income along the horizontal axis of a graph and shows the value of their income on the vertical

[7] Described in Pen (1974). A similar presentation using grouped data was employed by Reutlinger and Selowsky (1976).

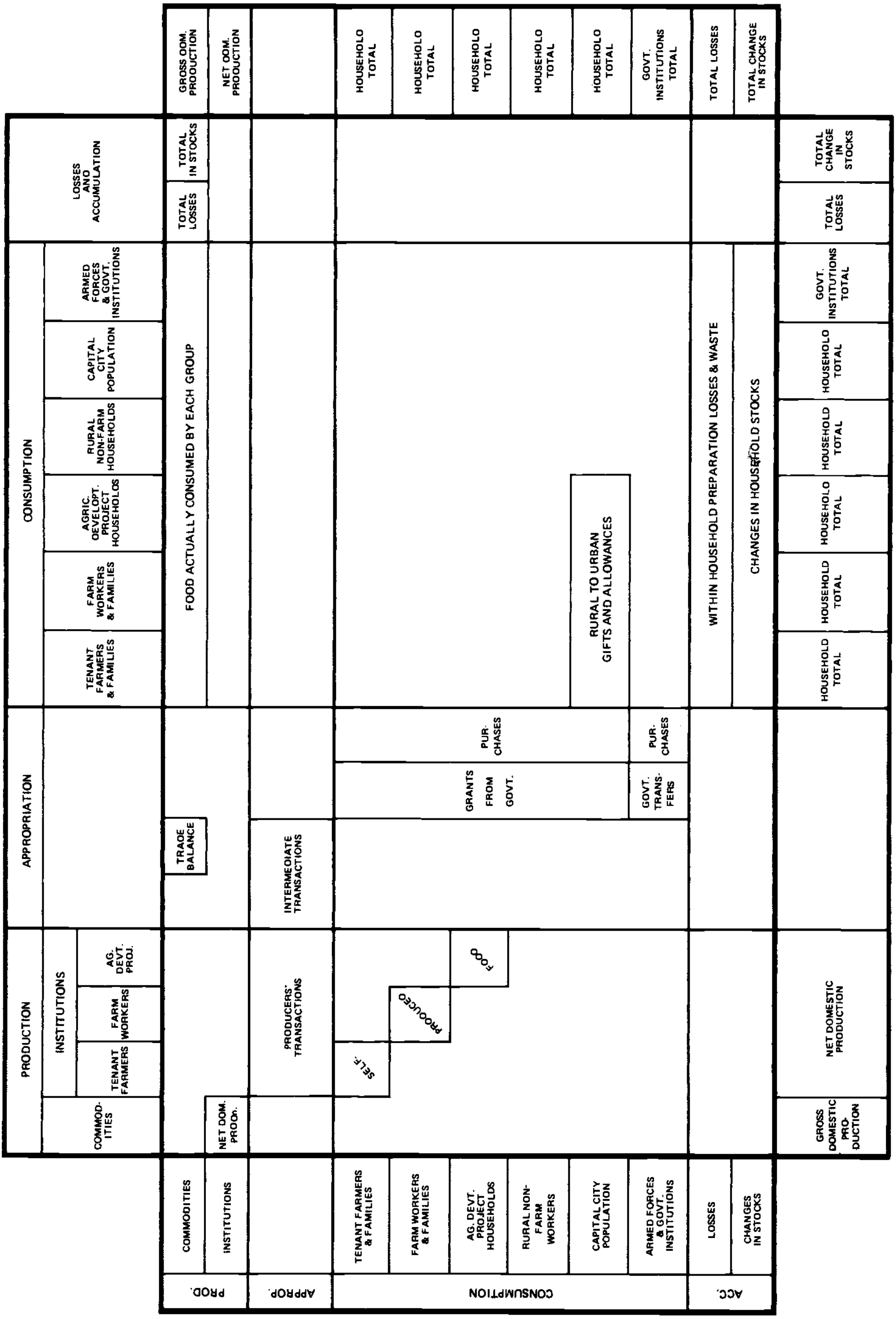


Fig. 4. An array of consumption accounts allocated to groups of households.

axis. Provided the frequency function representing the distribution of income is unimodal, this curve has the general shape shown in Fig. 5A. A comparable application of this idea to the distribution of food between households would be to rank households by increasing food acquisition along the horizontal axis and to show the amount of food acquired in a given period on the vertical axis.

However, the idea may be extended in order to present data from production as well as consumption accounts. For example, holdings may be ranked by increasing output and the amount produced plotted against the vertical axis. In fact, the ranking parameter need not be the same as the variable being displayed. Suppose income (or total expenditure) per household is the attribute chosen to rank the households involved and, as a first step, income is shown for the group. The disposal of income to food represents a segment of the area under the first curve and provided the propensity to consume remains positive another monotonic cure can be constructed to show the way household food demand is distributed. Maintaining income as the attribute which determines the order in which households appear, the expenditure on food in money terms can be converted to physical units bought if price is known and the results re-plotted to show commodities purchased on the vertical axis against households ranked by income. Further disaggregation by commodities may be possible but it would be expected that the plot for inferior commodities would show a downward trend as income increases.

An analogous sequence may be used to trace the effects of the distribution of area under cultivation per holding on the distribution of output and its disposal to seed, sales, own consumption and losses.

The features which make this form of presentation attractive are as follows. Although a graph of the kind shown in Fig. 5A is best visualized as a line of best fit through a set of real data points, a function representing this curve is related mathematically to the corresponding cumulative frequency function. Thus, if the cumulative frequency function of production per holding is $F(p)$ then an 'order function' representing the ranked production per holding (p) of a group of N holdings, where a particular holding is of rank number (r) is given by

$$p = F^{-1}(r)$$

Thus, in theory at least, the probability density function, $f(p)$, representing the dispersion of production among the holdings, which has readily identifiable relationships with commonly used statistics, can be transformed into an 'order function' provided the total number of holdings is also known.

A good deal of information can be derived directly, or by quadrature, from a graph of this kind. The general shape of the curve provides an immediately accessible picture of both the amount available to, or produced by, individual units in a group, and also the total amount available to, or produced by, the group as a whole. This total, represented by the area under a curve or in analytical terms by

$$\int_1^n F^{-1}(r)$$

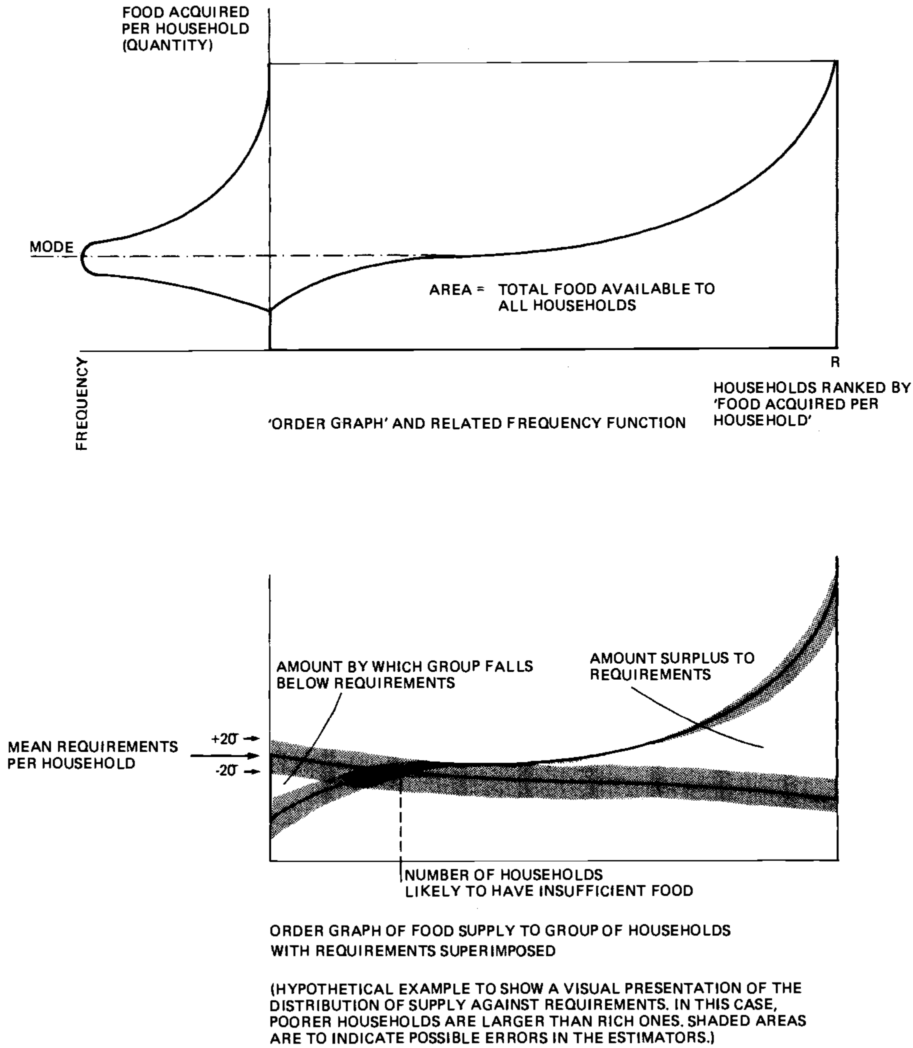


Fig. 5. Graph of household food acquisitions ranked by ascending amount of food acquired.

appears in a corresponding cell in the matrix. Suitably constructed order graphs can be used to demonstrate the distribution of commodities represented by the totals given in each cell of the production and consumption accounts. Alternatively, instead of showing disposals of output and income, segmented order graphs may be used to show patterns of production for different sizes of holdings and the pattern of foods consumed at different levels of consumption.

These graphs are not standardized. The length of the horizontal axis bears a direct relationship to the number of holdings or households in the group. A plot of food requirements per household based on the size of each household can therefore be superimposed on an order graph of food supply per household. The area under the plot will represent the total requirements of the group, and the point where the graphs cross will mark off households in deficit food balance from households having a surplus (Fig. 5B). At our present state of knowledge, because individual food needs vary in a way which is ill-understood, nutrient requirements are best represented by a symmetrical probabilistic function.[8] This could be indicated by an envelope of probabilities surrounding a graph which traces out mean requirements per household taking into account household sizes and composition. Household size often varies systematically with size of holding or income. In this case the requirements plot would not be horizontal.

The method has been tested using graphical methods on production, income and expenditure data. Although some of the data was already grouped so that the method involved approximations, the results are sufficiently interesting to suggest further investigation.[9]

Problems of specification and estimation have yet to be explored thoroughly. In practice it is probable that the specification of a line of best fit through a set of data points will be less precise at the ends of the range, in the same way that the specification of the tails of a frequency function can pose problems.

The transformation of production, supply and consumption functions into 'order function' format is straight-forward using graphical methods and the use of functions representing plots of this kind appears to offer interesting possibilities for the study of the way household food supply changes as a result of changing environmental, technological or policy conditions.

An Application

In this section the method will be illustrated using a set of data which is fairly typical of many countries in Africa. For reasons of confidentiality no direct reference will be made to the country in question but the sequence illustrates, not only an approach to the application of a FAM, but also the efforts being made by the government to apply the method to their planning problems. It should be emphasized that the purpose of this exercise was to illustrate the method to government officials. The results could have been improved if more time had been devoted to sifting through government sources. It was felt that this was not worthwhile as the situation had already changed so much that the results would have been only of historical interest. Contemporary application has involved considerable changes in design and in the types of data being collected.

The population of some 28 million was predominantly rural. At the time, apart from a small number of farmers receiving credit from a government agency, there

[8] See: Mats Lörstad (1971).

[9] All the data we have examined has behaved surprisingly well, in accord with Sutton's observation: 'I know of scarcely anything so apt to impress the imagination.... It reigns with serenity and in complete self-effacement amidst the wildest confusion. The larger the mob, the greater the apparent anarchy, the more perfect its sway.... Whenever a large sample of chaotic elements are taken in hand and marshalled in order of their magnitude, an unsuspected and almost beautiful form of regularity proves to have been latent, all along': quoted in Tippet (1975).

was little capital investment in agriculture. Most of the farmers grew cereal crops for their own consumption, selling the 'surplus'. Cash cropping for export was common in one region of the country. The accounting period chosen to demonstrate the method began in July 1977 and ran for twelve months. A recent reform of land tenure had allowed peasant farmers to control the disposal of their production. Rural-urban food flows had fallen for a number of reasons, not least that the farmers' new freedom had resulted in higher on-farm consumption. In addition some rural areas were experiencing production deficits due to crop pests, disease and poor rains, superimposed on long standing problems of soil erosion and population pressure.

The points the FAM was designed to demonstrate were as follows:

(i) the relative positions of farmers receiving credit, and those without an obvious source of capital

(ii) the food supply of urban households faced by steeply rising food prices, and

(iii) the role of food aid and commercial imports in meeting food deficits.

Fig. 6 shows the design of the FAM. The commodities chosen for this exercise were all the main cereal types, pulses and oilseeds. To save space these commodities have been grouped as 'fine grains', 'course grains', 'pulses' and oilseeds. Insufficient data were available to include animal products and vegetables. Fish is not a very important item in the diet. Producers were divided into three groups. Those not receiving government credit were designated Rural I in Fig. 7 and appear in the matrix as both producers and consumers. Population estimates were not considered to be very accurate but this group was thought to comprise 4.6 million holdings and the same number of households. Farmers receiving credit were designated Rural II and also appear as producers and consumers. It was estimated that this group numbered 186,000 holdings. Pastoralists who are dependent on animals but who grow crops in good years and who buy cereals regularly were designated Rural III but no data were available for this group. A fourth production account was allocated to 'State Farms' which represented an important government effort to ensure market supply during a process of socialist transformation in the countryside.

Consumption accounts were allocated to groups of self-provisioning producers (RI–RIII) and to wholly market dependent households (Urban).

The 'appropriation' section of the matrix was designed to show the main structures and institutions influencing commodity flows. The government acted as a marketing agency. It purchased all state farm output and a considerable amount of cereals from small holders. The country was in receipt of food aid and was a net commercial importer of food.

Grouped production data came from government statistical records: a sample survey of current agricultural production for the year in question and from a World Bank report covering the same period. The distribution of land holdings and output for the two groups of cultivators is shown in Fig. 7. Holdings were ranked by size. The scale of the vertical axes (hectares in one case and quintals in the other) is the same for the two groups, but it was not possible to show the number of holdings in the two groups on the same scale. However, by comparing the area under the graphs and their shape it is possible to see how land and output is

		PRODUCTION					APPROPRIATION				CONSUMPTION				ACCUMULATION		
			INSTITUTIONS														
		COMMODITIES	RURAL I	RURAL II	RURAL III	STATE FARMS	MARKET	GOVERNMENT	AID	REST OF WORLD	RURAL I	RURAL II	RURAL III	URBAN	LOSSES	CHANGE IN STOCKS	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
COMMODITIES	1	SEED								EXPORTS MINUS IMPORTS	FOOD CONSUMED				TOTAL LOSSES	TOTAL CHANGE IN STOCKS	GROSS DOMESTIC PRODUCTION
RURAL I	2	NET PRODUCTION															NET DOMESTIC PRODUCTION BY INSTITUTION
RURAL II	3																
RURAL III	4																
STATE FARMS	5																
MARKET	6		SALES BY DOMESTIC PRODUCERS					SALES BY GOVERNMENT									MARKET TOTAL
GOVERNMENT	7						PURCHASES BY GOV'T		AID-GOVT. TRANSFER	IMPORTS BY GOVT.							GOVERNMENT TOTAL
AID	8							GOVT. AID TRANSFER		IMPORTS BY AID							AID TOTAL
REST OF WORLD	9							EXPORTS									TOTAL EXPORTS
RURAL I	10		PRODUCTION RETAINED FOR CONSUMPTION				FOOD PURCHASED										RURAL I FOOD TOTAL
RURAL II	11								FOOD AID								RURAL II FOOD TOTAL
RURAL III	12																RURAL III FOOD TOTAL
URBAN	13																URBAN FOOD TOTAL
LOSSES	14	FIELD LOSSES	POST-HARVEST LOSSES				STORAGE LOSSES				WITHIN HOUSEHOLD/ MILLING LOSSES						TOTAL LOSSES
CHANGE IN STOCKS	15		CHANGE IN PRODUCERS STOCKS				CHANGE IN TRADERS STOCKS	CHANGE IN GOVERNMENT STOCKS	CHANGE IN AID STOCKS								TOTAL CHANGE IN STOCKS
	$\sum$	GROSS DOMESTIC PRODUCTION	NET DOMESTIC PRODUCTION BY INSTITUTION				MARKET TOTAL	GOVERNMENT TOTAL	AID TOTAL	TOTAL EXPORTS	HOUSEHOLD FOOD TOTALS				TOTAL LOSSES	TOTAL CHANGE IN LOSSES	

Fig. 6. Demonstration FAM design.

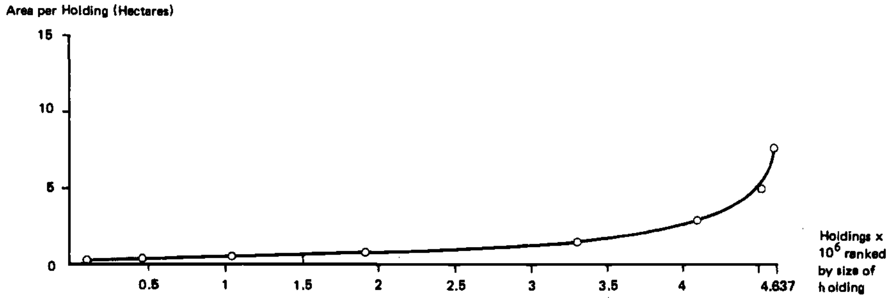
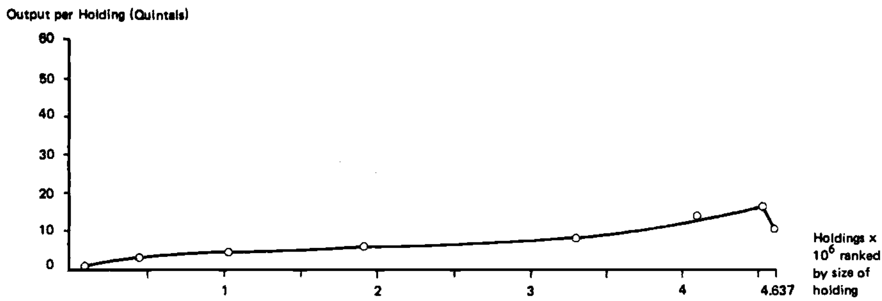
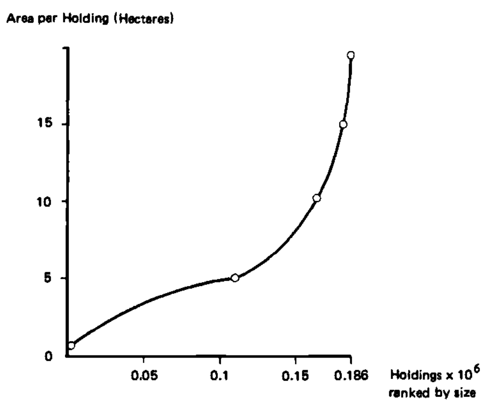


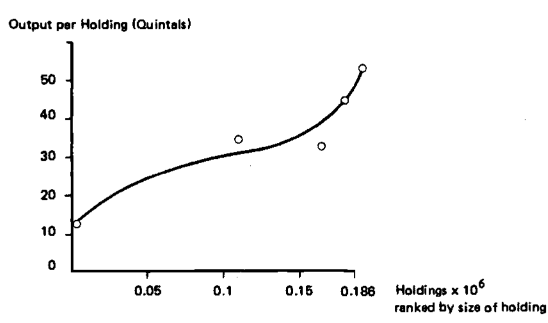
Fig. 7. Farmers not receiving government credit (Rural I) Area per holding in order of magnitude.



Farmers not receiving government credit (Rural I) Output per holding ranked by size of holding.



Farmers receiving government credit (Rural II) Area per holding in order of magnitude.



Farmers receiving government credit (Rural II) Output per holding ranked by size of holding.

distributed within each group and how farmers receiving credit are relatively better off, both in terms of resource endowment and performance. Indeed, despite their small numbers, they contribute a significant proportion of market supply. The fall off in output at the upper end of the scale in Fig. 7 reflects the high proportion of unused land in large holdings. Had holdings been ranked by 'cultivated area' this would not have occurred.

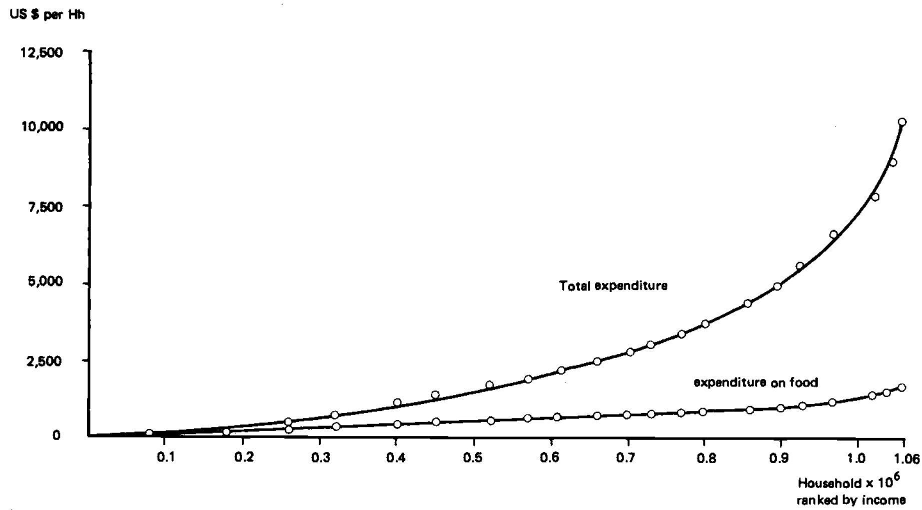
It was estimated that just over one million households in the country were wholly dependent on the market for food. The only consumption data readily available came from a household budget survey carried out in the capital city two years before. During the intervening period the retail food price index had risen from 175 to 303. For demonstration purposes only, these data were used to stand for all market dependent households (urban and rural non-farm). Without computational facilities a simple model of consumer behaviour was applied to simulate the change in the pattern of food demand between 1975 and 1977 assuming that incomes had increased by about 18 per cent during the same period. The model was based on the assumptions that all households faced the same prices and that they allocated their income under 1977 price and income conditions in a way established by poorer households under 1975 price and income conditions. The demand for all cereals was calculated first using a log–log consumption function fitted by OLS to 1975 data. The demand for all cereals in 1977 was then estimated at new incomes deflated by the change in the retail cereal price index. The demand for the favoured commodity was then examined in a similar way using, in this case, the change in actual price to estimate new demand. Table 1 shows the results of fitting log–log functions to the survey data together with a measure of the variance explained by the equations (r^2). Finally, total demand was adjusted within the matrix from estimates of total market supply. This experiment was a crude application of common assumptions applied to the estimation of changed demand using cross-sectional data. The original data are shown in the form of order graphs in Fig. 8 and the results of the experiment in Fig. 9. The main features of the changes illustrated are a substantial move by poorer households to the inferior good but the maintenance of demand by richer households for the favoured commodity. These results were not unexpected and in fact accord with the reality of the time, but refinements to the model might have produced

TABLE 1

Annual Household Income and Expenditure on Food: Relations between income (Y) and Expenditure (E) at 1975 Prices

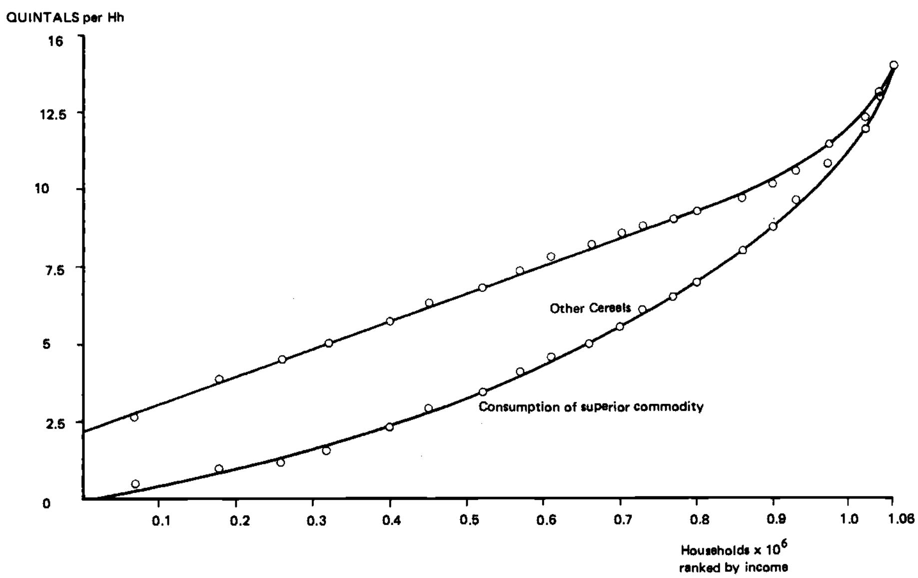
Cereals	..	$\log E = 0.303 + 0.473 \log Y$ ($r^2 = 0.96$)
Pulses	..	$\log E = -0.146 + 0.290 \log Y$ ($r^2 = 0.49$)
Oilseeds	..	$\log E = -2.794 + 0.709 \log Y$ ($r^2 = 0.88$)
Meat	..	$\log E = -3.228 + 0.956 \log Y$ ($r^2 = 0.85$)
Dairy Produce	..	$\log E = -2.511 + 0.880 \log Y$ ($r^2 = 0.94$)
Bread	..	$\log E = -3.918 + 0.831 \log Y$ ($r^2 = 0.38$)

Note: The equations were estimated from the averages of 30 income groups.



Retail price index against base year 1970

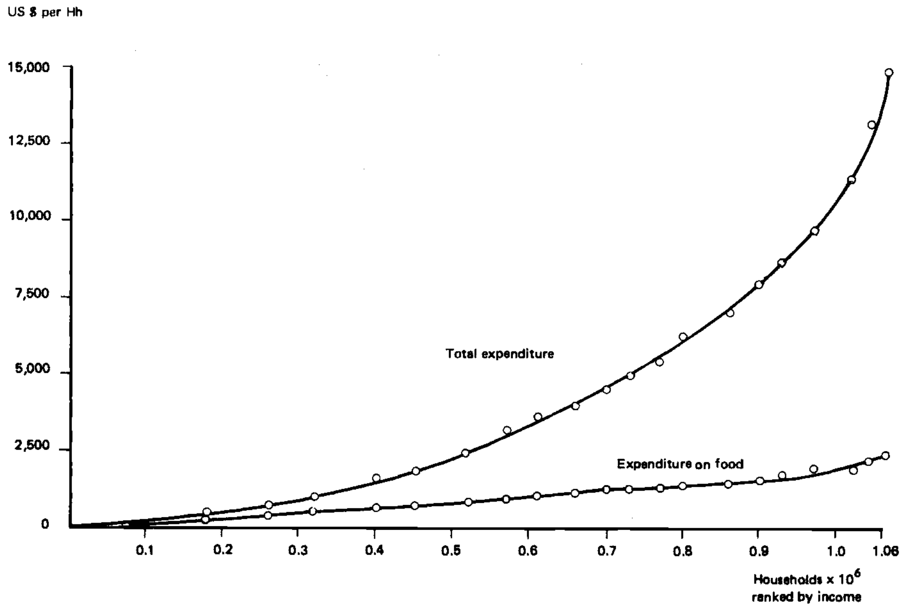
All Food	..	175.1
Cereals	..	144.7
Pulses	..	162.8
Oilseeds	..	163.4
Meat	..	187.8



Annual purchase of cereals at 1975 prices

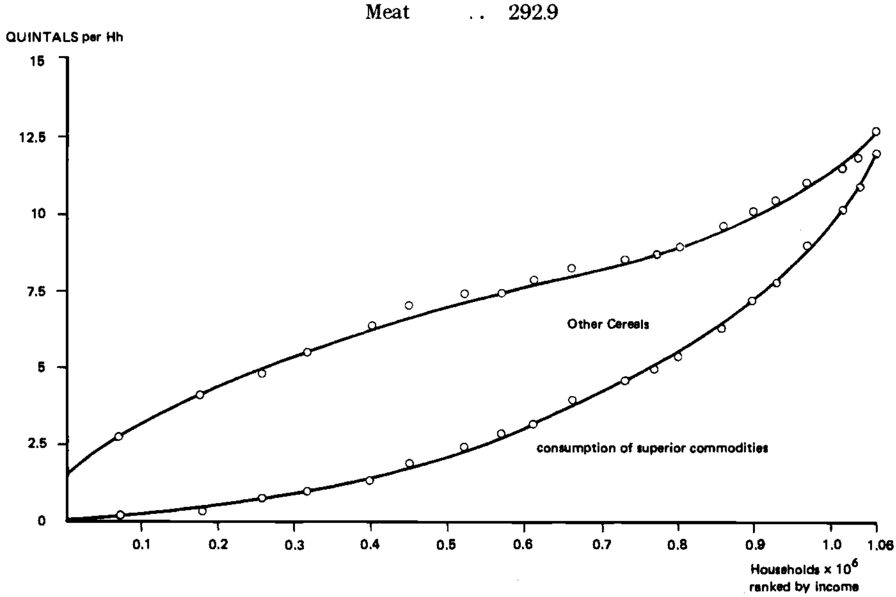
Superior Commodity	US $24/Qt
Other Cereal Commodities ..	US $12.5/Qt

Fig. 8. Annual household income and expenditure on food at 1975 prices calculated from OLS model fitted to sample survey data from the capital (n = 295 Hh).



Retail price indices against base year 1970.

All Food	..	303.8
Cereals	..	292.3
Pulses	..	254.1
Oilseeds	..	278.9
Meat	..	292.9



Estimated annual purchases of cereals at December 1977 prices.

Superior Commodity	US $38.5/Qt
Other Cereal Commodities ..	US $21.0/Qt

Fig. 9. Annual household expenditure and expenditure on food at December 1977 prices. (Results of Modelling Experiment)

better results. There was no easy way of checking the results under the circumstances.

The simulated consumption data together with the production data already discussed and account data obtained from government institutions were entered in the matrix. The result is shown as commodity aggregates in Fig. 10 and disaggregated by commodity group in Fig. 11.

With growing government interest in the method, new classifications of producers have been developed to emphasize processes going on in the countryside. New appropriation accounts have been added to reflect new planning problems which have been identified. This design is now being used to influence the identification of producers during current survey activities and to guide data collection from institutions which handle food commodities.

The process has, therefore, completed a full circle from a design which was severely limited by data availability used to demonstrate the method, through a stage of preliminary data analysis, to a more precise definition of commodity flows and therefore of problems which require attention. As a result the matrix has been redesigned and, in turn, has influenced data collection.

Discussion

Matrices have been used widely to provide the framework for the examination of disaggregated data from various sources. They also form the basis for important analytical processes and are embedded in a number of large scale multi-sectoral models. However, while they have been used to investigate the problems of development and in particular to elucidate the growth-distribution issue, they have not, by and large, become a normal planning tool in third world countries.[10]

In offering yet another matrix the primary objective is not to supply a research instrument or a device for international comparisons but to suggest an approach to the collection and analysis of data on food availability in third world countries by third world planners. Thus, the question, 'are there enough data available?' is not a valid criticism of the method as the development of a statistical apparatus and analytical capacity should be mutually reinforcing. Flexibility and adaptability rather than a strict method have therefore been emphasized in this description.

Its restricted scope may mean that in due course it will be superceded by more sophisticated devices which capture inter-sectoral linkages more explicitly. However, many third world country planners are in urgent need of a device to help them use and extend their data collecting and analysis systems rationally.

In this paper many real problems have been ignored in order to concentrate on general principles. The definitional problems which have been the subject of a great volume of work by others have been glossed over. What is a 'production unit', a 'consumption unit'? Is income per household, or per individual, or per adult equivalent a better measure of household purchasing power? In many cases these

[10] For a review of development models and in particular the use of input-output matrices and SAM's see: Hopkins and van der Hoeven (1979).

		PRODUCTION					APPROPRIATION				CONSUMPTION				ACCUMULATION		
			INSTITUTIONS														
		COMMODITIES	RURAL I	RURAL II	RURAL III	STATE FARMS	MARKET	GOVERNMENT	AID	REST OF WORLD	RURAL I	RURAL II	RURAL III	URBAN	LOSSES	CHANGE IN STOCKS	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
COMMODITIES	1	2,996 Data								-1,485	22,374	1,356	2,637	3,526	7,260	0	38,664 Data
RURAL I	2	26,948															26,948
RURAL II	3	5,432															5,432
RURAL III	4	–															No Data – Taken as Zero
STATE FARMS	5	332															332
MARKET	6		6082	3,938	–	332		2,130 Data									12,482
GOVERNMENT	7						1,125 Data		110 Data	1,185							2,420
AID	8							170 Data		335							505
REST OF WORLD	9						35										35
RURAL I	10		20,866				3,171 Model		288								24,325
RURAL II	11			1,494			105 Model		0								1,599
RURAL III	12				–		2,689 Model		88								2,777
URBAN	13						4,888 Model		0								4,888
LOSSES	14	2,956	0	0	–	0	469	120	19		1,951	243	140	1,362			7,260
CHANGE IN STOCKS	15		0	0	–	0	0		0								0
		38,663 Data	26,948	5,432	No Data – Taken as Zero	332	12,482	2,420	505	35	24,325	1,599	2,777	4,888	7,260	0	

Fig. 10. Demonstration FAM: Aggregate Commodity flows, June 1977–June 1978. Units: Quintals × 10^3

			PRODUCTION								APPROPRIATION										CONSUMPTION				ACCUMULATION		
			COMMODITIES				INSTITUTIONS				MARKET				GOVT.	AID				ROW							
			CEREALS	SORGHUM & MILLET	PULSES	OILSEEDS	RURAL I	RURAL II	RURAL III	STATE FARMS	C	S&M	P	O		C	S&M	P	O		RURAL I	RURAL II	RURAL III	URBAN	LOSSES	CHANGE IN STOCKS	
			1				2	3	4	5	6				7	8				9	10	11	12	13	14	15	
COMMODITIES	CEREALS	1	1,949																	-1,410	17,195	824	708	3,085	4,483		26,834
	SORGHUM & MILLET			97																-100	3,119	369	1,930	130	1,095		6,640
	PULSES				912															25	1,751	135	0	258	1,459		4,540
	OILSEEDS					37														-0	310	28	0	53	222		650
RURAL I		2	19,665	4,299	2,585	496																					26,948
RURAL II		3	3,329	1,413	583	107																					5,432
RURAL III		4																									—
STATE FARMS		5	85	237	6	4																					332
MARKET	C	6					4,438	2,414		85					1,970												8,807
	S&M						954	1,024		237					46												2,261
	P						583	423		6					96												1,108
	O						108	77		4					17												204
GOVERNMENT		7									957	12	152	39		110	0	0	0	1,185							2,455
AID	C	8													110					325							435
	S&M														60					0							60
	P														0					0							0
	O														0					10							10
REST OF WORLD		9													35												35
RURAL I		10					20,886				2,602	0	500	69		271	8	0	10								24,326
RURAL II		11						1,494			62	0	32	10													1,598
RURAL III		12							—	—	705	1,986	0	0		40	48	0	0								2,779
URBAN		13									4,290	153	388	76													4,887
LOSSES		14	1,805	664	454	33					290	113	55	10	120	14	4	0	0		1,952	243	139	1,362			7,258
CHANGE IN STOCKS		15																									0
Σ			26,836	6,640	4,540	650	26,847	5,432	—	332	8,808	2,264	1,107	204	2,454	435	60	0	10	35	24,327	1,599	2,777	4,888	7,259	0	

Fig. 11. Demonstration FAM: Commodity flows by commodity group, June 1977–June 1978.
Units: Quintals × 10^3

will remain problematic issues but experience to date suggests that the overwhelming disparity between food available to the rich and food available to the poor makes these errors, if not trivial, at least relatively unimportant, provided limits of precision are recognized. The problems of collecting data, data processing capacity, statistical and planning organization and the like have not been touched. These are both in a theoretical and practical sense profoundly important.

The method suggests yet another look at what is generally known as the 'aggregation problem'. Matrices provide great scope for dealing with disaggregated data. This feature has been applied to the analysis of food commodity flows. The method also makes possible the presentation of differences in production and consumption within groups. The way in which producers and consumers are classified has a direct bearing on the allocation of production and consumption accounts in the matrix and should reflect, not only distinguishing group characteristics, but also relationships between groups. The problem of classification is a common one. It is always a compromise between too much aggregation with loss of information, and the desire to treat units individually, which is usually marred by the presence of aberrant cases and by a complexity of detail.[11]

The use of ordered data suggests an approach to the problem of 'optimum classification' for a given purpose. The method removes the need to classify units by size of holding or size of income as large and small, and rich and poor, can be accommodated together without loss of information. Instead, optimum classification is achieved when the grouping results in minimum variance about a line fitted to ranked values. Suppose for example, food consumption data are being plotted for a group of households ranked by their income. A minimum scatter of points will be achieved when households in the region of a given level of income demand much the same amount of the same kinds of food. Similarly, if the output of holdings ranked by size of cultivated area is plotted, the variances about a line of best fit will be least if, in the sample, holdings having about the same cultivated area achieve much the same productivity. Conversely, group homogeneity will be reduced if the group contains, for example, consumption units which, at similar levels of income, spend significantly different amounts on food, such as might occur between different ethnic groups.

This approach provides an additional measure of freedom to examine other attributes which govern behaviour. Thus, for example, attention might be focussed on the characteristics and constraints which determine the level of output for a given size of holding, such as land quality and level of technology, or those which determine the disposal of output at a given level of output, such as tenurial relations, access to markets and degree of monetization. Attributes which are likely to discriminate well between consumers are those which determine the pattern of disposal of income, such as a social group, race, extended family obligations or life cycle attributes. In practice, a useful approach would be to examine pilot survey data by grouping them in various ways and applying 'best fit' tests to determine the optimum classification.

[11] This general problem is treated in the context of consumer behaviour in Brown and Deaton (1973) *op cit.*

It would also seem reasonable to expect that the grouping of units in this way would improve the results of modelling experiments which assume consistent behaviour over time. If, for example, individual households are expected to behave under changed conditions like their group superiors (or inferiors) used to behave, then it would seem likely that an initial grouping of households displaying systematically varying behaviour over a range of entitlements would be the most satisfactory starting point for modelling experiments. Most models which rely on cross-sectional data to predict future behaviour embody assumptions of this kind.[12]

There are limits to disaggregation. The data required to support complex investigations are considerable. In the event, the practical circumstances of a study, and, in particular, the way a government policy is to be implemented may dictate the best way of classifying producers and consumers and, therefore, the allocation of accounts in the matrix. For example, the simple allocation of accounts to administrative areas may produce the most useful results. In addition, the practical problems of identifying the characteristics of units of production and consumption in advance to ensure efficient sample design are considerable. These questions are under review and will be examined elsewhere.

Finally, static analysis, while rewarding, does not illuminate a process. Equilibrium is not a characteristic of third world economies. Change, the dynamics of relationships between groups, and the results of the processes are where the real problems and interest are to be found.

Much more experience is required before the method is thoroughly tested but it raises interesting questions which invite pursuit. Social relations in the process of development are expressed by commodity and value flows, levels of productivity, types of economic activity and the relative command households have over the market. These, at least as they determine structural relations and influence food commodity flows, can be captured by the design and data of a Food Accounting Matrix.

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[12] See for example, the application of a model based on the Slutsky identity in: Mellor (1978).

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