THE STATISTICS OF THE WORLD FOOD PROBLEM:

A REVIEW ESSAY

By

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In the years since World War II, a number of world food surveys have been undertaken in an attempt to assess the extent of food needs and food consumption levels of different peoples of the world. The Food and Agriculture Organization (FAO) published the first World Food Survey in 1946 (21). This was followed by a second in 1952, and a third more comprehensive survey appeared in 1963 (20). In the United States, the Economic Research Service of the USDA had maintained a series of food balance sheets for most free world countries for several years. In October 1961, a comprehensive World Food Budget was published (35). This study attempted to measure world food production and consumption by regions and countries in 1958, and projections of food supplies and food needs were carried forward to 1962 and 1966. Two years later an improved World Food Budget appeared with projections of food supplies and food needs to 1970 (36).

These studies must be credited with defining the nature of the world food problem. Positively, they have served to focus attention on the existence of widespread hunger and malnutrition in many parts of the world; negatively, they have tended to create the less than accurate impression that all developing countries are characterized by near starvation conditions, which they themselves can do little to ameliorate.

In this paper an attempt will be made to take a capsule look at the world food problem from the perspective of these studies. The first section outlines briefly the salient features of the FAO and USDA studies; the second section analyzes in some detail the methodology employed, together with the principal limitations of this methodology; and the third

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section discusses some of the aprroaches which researchers currently are exploring in an effort to precise and improve our understanding of the world food problem.

I. The World Food Survey Studies

A. The First World Food Survey (FAO, 1946).

In 1946 the FAO commissioned a group of experts to prepare an overall picture of the food consumption levels and the food requirements for the world's population in the pre-war period. From a careful study of the best available data, recognized as grossly inadequate in many if not most instances, the Commission issued a survey report which covered some 70 countries and 90 percent of the world's population. Answers were sought for these four fundamental questions: 1) what is the food consumption of the different countries?; 2) how does it compare with their needs?; 3) where are the most serious shortages?; and 4) what kinds of foods and what quantities of each are required to improve nutrition throughout the world? (21, pp. 1-5).

Any path-breaking study of this nature finds that it first must define the terms and rules within which it operates. These then form the basis for subsequent studies and in no small part determine man's understanding of and approach to the problem itself. Thus "food consumption" somewhat illogically was defined as the amount of food available "at the retail level," rather than "food ingested" by the individual consumer. Food consumption figures were arrived at from country and regional production estimates (acreage and average yields of major crops), trade in major foodstuffs between countries, and changes in stocks, with appropriate adjustments for amounts used in feed, seed, manufacturing, or simply waste. Depending upon the reliability of the data and the accuracy of the estimates at each step, the resulting calculations provided a more-or-less reliable figure for the estimated quantity of foods supplied at the retail level over a given time-period, usually a year. By means of conversion tables, these foodstuffs were expressed in common nutritive values such as calories or protein units. The shortcomings of this approach were recognized by the FAO group; both the approach and its limitations will be discussed at length in the second part of this paper.

The question of food needs obviously demanded some estimate of population numbers as well as basic requirements for individual groups within the population. Since census data were lacking or inadequate for many countries, population estimates were arrived at by means of existing sample surveys or simply best guesses (21, pp. 14-18). Per capita food supplies were calculated on the basis of such population estimates, and the results were compared against generally accepted nutritional requirements.

The Survey report mapped a large area, the home of over one-half of the world's population, where food supplies available at the retail level were estimated to be insufficient to provide 2250 calories per person daily. A second area, with approximately one-third of the world's population, provid d food supplies in excess of 2750 calories per person per day, and the remaining area, with one-sixth of the world's population, had food supplies between these two levels. Not unexpectedly, these regions roughly coincided with the affluence of a country as measured by per capita income, the poorer countries having the lowest per capita calorie consumption (21, pp. 6-10).

On the basis of their pre-war food supply estimates and utilizing the nutritional standards recommended by the FAO Nutritional Committee, the Survey Commission established nutritional targets for countries and regions which would improve the nutritional value of diets without altering the general dietary patterns too greatly. A daily per capita intake of 2550-2650 calories was established as the minimum desirable level. The Commission further specified this by indicating the range of calories to be derived from each of eight major food groupings. In general, countries with low and medium calorie intake were advised to increase cereal consumption. Countries with low protein intake were advised to increase consumption of meat, fish, and eggs (21, pp. 10-14).

The Commission clearly recognized the limitations and the tentative conclusions of this first World Food Survey. Nevertheless, this undoubtedly was the best estimate of the magnitude of the world food problem confronting mankind. At the same time it emphasized the importance of additional research and the development of much more adequate data sources, especially in the developing countries. Lord Boyd-Orr, the Director General of FAO, might be forgiven if he overlooked these limitations and emphasized the conclusions in his eloquent plea on behalf of the world's hungry, among whom he numbered two-thirds of mankind (2).

B. Second World Food Survey (FAO, 1952).

In the light of revised estimates for the prewar period (1934-38) and the changes which had taken place in the immediate postwar period (1949/50 or a 3-4 year average), this second Survey considered the same basic questions proposed by the first Survey Commission. Postwar estimates on 52 countries were now available, and the extent of postwar recovery in food production was obtained by examining the trends in per capita production for each region of the world. Estimated supplies available at the retail level were calculated for eight major food crops in each region of the world. Per capita production was obtained by converting each crop into a common unit such as a wheat equivalent, and then expressing this as an index of prewar production.

This survey established much more realistic standards in its assessment of food requirements. As before, calories were used as a measure of the quantity of food needed to meet energy requirements, but such factors as size, age, sex, activity, and climate also were taken into account in estimating the average calories required by different population groups (19, p. 12). To evaluate nutritional quality, no relatively simple unit like calorie content was available. The best available indicator appeared to be protein content, because most foods rich in protein also contained other nutrients essential for body growth and health.

To estimate individual energy and food requirements, the FAO Commission utilized a reference man and woman as a norm (14, pp. 10-14). The reference male was 25 years of age, weighed 65 kilograms, and lived in a temperate zone with mean annual temperature of 10°C. He was a healthy member of the species, ate a reasonably balanced diet, and spent 8 hours of his normal working day in non-sedentary activities. Such a man was assumed to require 3200 calories daily throughout the year. His counterpart, the reference woman, was of the same age and lived in the same environment. She weighed 55 kilograms, and she was assumed to require 2300 calories daily for the entire year. Once the reference requirements for the adult man and woman were established under well defined conditions, adjustments could be made for each of the relevant factors (14, pp. 15-27). In addition, an allowance of 15% for wastage up to the retail level was added to the calculated physiological requirement. In this manner the estimated per capita requirement could be compared with the calorie content of the estimated food supplies available at the retail level.

The Survey report emphasized the tentative nature of the method, the shortcomings involved because of the paucity of the data, and the difficulties encountered in estimating body weights and environmental temperature. Thus the average calorie requirements could be no more than a rough guide in assessing the adequacy of average consumption levels, for even estimates based on the most complete data were subject to a wide margin of error. With these caveats, national food supply and demand figures were presented, more to illustrate the broad aspects of the world food situation than to set up definitive requirements for each country.

The results of the Second World Food Survey indicated that in areas with some 60% of the world's population, food supplies at the retail level were inadequate to provide the population with even 2200 calories per person per day. Diets were quantitatively insufficient in the most heavily populated regions of the world. The food situation was found even more unfavorable in terms of nutritional quality as measured by protein content (19, pp. 12-16).

Food consumption targets were drawn up for 1960, in much the same manner as in the first Survey. Again they represented a compromise between what the Survey Commission considered desirable from a nutritional standpoint and what appeared to be feasible in practice. But to talk of feasibility is to introduce a host of related issues such as land reform, credit provision, price incentives, and other public policies (19, p. 17).

C. Third World Food Survey (FAO, 1963).

This third Survey attempted to give a comprehensive picture of the present and past world food picture with the limited objective of presenting some idea of the order of change in food supplies needed to raise the level of nutrition for the people of the world. Three periods were examined: prewar (1934-38), postwar (1948-52), and recent (1957-59) (20, pp. 6-7).

During the 11 years intervening since the Second Survey, a great deal of work had been done to improve the statistical base of both food supply and food requirement sides of the ledger. Food balance sheet data, while still inadequate in most instances, were available for over 80 countries covering some 90 percent of the world's population. More accurate national population censuses or surveys had been undertaken during this period, and many countries had conducted food consumption studies, nutritional surveys, and other related studies among parts of their population. In addition, special FAO Committees had specified more precisely the quantitative and qualitative dietary requirements of various population groups (13, 11).

The expected caveats again were voiced concerning the limitations of the method and the approximate nature of the final estimates of food supplies and food requirements. Throughout its broad conclusions, the Survey expressed alarm over the widening disparity between the developed countries of the West and the developing regions in Asia, Latin America, and Africa.

Perhaps as a result of criticism, this report takes great care to distinguish between undernutrition or hunger and malnutrition. Undernutrition indicates a condition in which an individual's diet is so inadequate in quantity (calorie intake) that if continued over an extended period, the result is either loss of normal body weight or reduced physical activity or both. On the other hand, malnutrition indicates a condition in which the nutritional value of the diet is wanting in one or more essential nutrients. If such a diet is continued over some time, the individual suffers from a specific disease or general ill health. Most evidence indicates that the majority of undernourished people are also malnourished (20, pp. 36-52).

From dietary surveys which had been conducted in representative districts to ascertain the extent of undernourishment among different population groups, the Survey report estimated that some 20 percent of the population in underdeveloped regions were undernourished. Clinical survey data were insufficient to estimate the incidence of specific nutritional deficiency disease; but where diets derived more than 80% of th r calories from cereals, starchy roots, and sugar, the nutritional quality was considered inadequate. A conservative estimate was given that 60% of the population in low-income countries suffered from malnourishment. Thus the Survey concluded that 10-15% of the people of the world were undernourished and up to one-half suffered from hunger and/or malnutrition (13, pp. 8-10, 39-44, 48-51).

On the basis of the UN "medium" population growth projections to 1975, the Survey calculated that world food supplies must be increased by over 35% merely to sustain the world's population at existing dietary levels. If nutritional levels were to be improved, food supplies must be increased by at least 50% and animal products even more (13, pp. 73-74). The conclusions of this Third Survey were no brighter than those reached in the previous Surveys.

D. The World Food Budget, 1962 and 1966 (U.S.D.A., 1961).

This study, prepared and released by the Economic Research Service and Foreign Agricultural Service of the U.S.D.A. in the early years of the Kennedy Administration, was part of a program designed to utilize the mounting food surpluses in the United States in the alleviation of food shortages in other areas of the world. As a starting point, it attempted to measure world food production and consumption in 1958 and to project supplies and requirements forward to 1962 and 1966. It further assessed the adequacy of supplies available for consumption, i.e. at the retail level, against nutritional reference standards (35, p.7).

The Study divided the world into two general groups: the Northern Area of industrialized countries (excluding Korea and Communist Asia) and the Southern Area (excluding Australia and New Zealand), which included two-thirds of the world's population and all the diet deficient countries. The statistical bases for the study depended heavily on the food balance estimates prepared by the U.S.D.A. for some 80 free world countries and similar estimates prepared for Communist bloc countries. The method utilized in the study was generally similar to that employed by the FAO Commissions in preparing the World Food Surveys (35, pp. 7, 68-71).

A food balance sheet is designed to summarize the food supply situation of a country or an area by commodity or group of commodities for a given year. Following accepted procedures, it sets forth estimates which show domestic production, imports and exports, overall changes in stocks, and the total supply available for all uses. From this total, deductions are made for each commodity or commodity group for seed, feed, and industrial uses. A further deduction is made for wastage and for processing from the stage of production to the retail stage. The net result indicates the total supply available for human consumption. This figure is then broken down on the basis of population estimates into kilograms of food available per capita annually and into calories available per capita per day. Since much of the data and many of the assumptions involved are tenuous, the final estimates at best are rough approximations. In spite of this potential for error, the consumption levels estimated for 1958 appear to have indicated with considerable accuracy those countries where nutritional deficiencies existed.

Nutritional reference standards were required as a norm against which consumption could be evaluated to determine deficits in food supplies, and for this purpose the FAO requirements as published in the Second World Food Survey were adopted. Allowances were calculated for specific factor and regional variations in determining calorie requirements. Reference standards were also provided for animal and pulse protein as well as total protein, and this standard was applied to all countries. The total protein allowance of 60 grams per person per day at the retail level was considered adequate, with the proviso that this include a minimum of 7 grams of animal protein and enough pulse protein to bring the combined animal and pulse protein to 17 grams. In addition a reference standard of fat, expressed in terms that would provide 15 percent of the reference standard calories, was recommended (35, pp. 69-70).

From the 1958 levels a World Food Budget was constructed for 1962 and 1966. Food production was projected for each country and commodity production was projected for all countries. Population levels were also projected for each country for the same years. In those countries thought to have nutritionally adequate diets, requirements were determined by projecting effective demand based upon rising income levels, rising prices, and changing tastes. In nutritionally deficient countries, food requirements were calculated by the method noted above and the volume of exports necessary to meet the basic nutritional requirements of the population was calculated. The deficiencies were expressed in terms of well-known commodities: animal protein deficiencies in units of nonfat dry milk; pulse protein deficiencies in units of dry beans and peas; "other" protein and calorie deficiencies in units of wheat; and fat deficiencies in units of vegetable oil (35, pp. 18-27).

The study discussed in detail the dietary situation by regions, specifying what was generally known, viz., that the Northern Area countries by and large exceeded per capita nutritional allowances with some limited shortages, and that the Southern Area countries were experiencing a most serious food problem, with pronounced shortages in the Far East (35, p. 18).

E. The World Food Budget, 1970 (U.S.D.A., 1963)

This study was the result of expanded efforts by the Foreign Regional Analysis Division of the U.S.D.A. to evaluate the supply and utilization of food commodities for countries and regions of the world, to assess present and future needs, and to consider possibilities of meeting world food shortages. The coverage was extended to 92 countries with some 94 percent of the world's population. The statistical bases for the food balance estimates were improved, and special studies had been undertaken in 15 of the countries where supply and utilization data were particularly inadequate.

The approach followed in this study was essentially the same as that of its predecessor. However, considerably more attention centered on the factors affecting worldwide demand for food, reflecting a concern for future markets for U.S. agricultural products. The impact of population growth, urbanization, and rising incomes upon the demand for food commodities were noted. Although specific studies on income and price elasticities of demand had been completed in some low income countries, these studies were so limited in scope that no generalizations could be made. For most sub-regions, the price effect upon consumption of food was assumed constant and income elasticities between different food groups and between sub-regions with different income levels were derived from FAO estimates and U.S.D.A. research studies (36, pp. 15-22).

In terms of projected food requirements, per capita food consumption was expected to rise, especially for higher quality foods, and aggregate world demand was projected to increase more rapidly than population. The outlook for increasing food production was not considered hopeful for lower income countries, as per capita production levels had remained unchanged or declined in nearly all diet deficient sub-regions (36, pp. 39-50). World trade patterns strangely had contributed to this deficiency, as diet deficient areas were net exporters of food commodities. The 1970 projections expected exports to increase, but diet adequate areas would become net exporters to the deficient regions (36, pp. 51-63).

Lack of purchasing power within low-income countries appeared to be a nearly insuperable barrier to the expansion of world trade in food commodities. Increased food and preferential trading agreements in favor of less developed countries were suggested as means which might be taken to close the food gap. Perhaps Dumont's statement to the effect that at some future date the human community will look upon income and money as the ticket to admission to the world's food supplies in much the same manner as it now looks upon slavery bears repeating (8, pp. 255-260).

This second U.S.D.A. report concluded with specific policy recommendations that might be enacted by developing countries as well as by the United States (36, pp. 64-70). Combined with the FAO studies, a picture of the magnitude of the world's needs for food was emerging. Granted that the conclusions were necess rily "best estimates" in many instances and that spokesmen for the hungry of the world perhaps overstated in absolute terms the extent of the food problem, these studies represented a major step in the identification and measurement of the world food deficit. That they contained limitations and wide margins of error was explicitly recognized and so stated by each study commission. In the next section some of these inherent limitations will be considered as we discuss in detail the methodology employed.

II. Methodology and Limitations of the World Food Studies

The FAO and U.S.D.A. Surveys intended that their findings be interpreted as broad indicators and general guidelines in the estimation of the magnitude and nature of the world food problem. Yet the tendency exists to give these tentative conclusions an objectivity and absoluteness which they cannot have, with the result that the actual nature of the food problem confronting mankind is misrepresented and often erroneously stated. It seems useful, therefore, to review the methodology employed and to explicitate again the limitations inherent in these studies.

A. Food Balance Estimates: The Supply Side of the Equation

The Food Balance Sheet is a statistical method which attempts to depict the availability of food for human consumption in a particular country for a given year (15; also cf. 9. Much of the discussion that follows is adapted from this paper). The food balance equation is made up of aggregate supply and utilization compenents. On the supply side three elements enter into the equation: (i) domestic production; (ii) net imports or net exports; and (iii) net changes in year-end food stocks. Ideally these three elements should sum to equal the six elements of the utilization side: (i) seed use; (ii) industrial "non-food" use (including alcoholic beverages as non food); (iii) animal feed; (iv) waste on farms and in distribution channels up to the "retail level"; (v) processing or extraction rate losses of certain commodities; and (vi) the net food supply available for human consumption at the so-called "retail level." The net supply of each commodity is expressed in per capita terms based upon estimated national production, and the per capita food availability--inexactly referred to as "consumption"--is shown in terms of calories and grams of protein available per capita per day (9, p. 181-183).

Ideally for each commodity the supply and utilization estimates should be independent and trustworthy. Moreover, the population and nutrient conversion figures should be reliable. In fact, not even those countries with the most reliable data approach these ideal standards, and in most developing countries food and population data are inadequate or simply non-existent. The result is that food balance sheets vary in reliability, depending on the judgment, creativity, and research time of the estimator. In some instances the estimates not surprisingly reflect the political exigencies of the moment.

The estimates of wheat production figures in the United States and Canada are often cited as the "model" format for the construction of a balance sheet. Direct, independent estimates are available for acreage and yields per acre, and these estimates may be checked and cross-checked at various levels for consistency and sampling errors. Total supply estimates can be checked against utilization figures, but even here some margin of error exists. The least satisfactory direct utilization element is that of animal feed, and this is often considered as a residual (9, pp. 183-184).

Even within such countries as the United States, Canada, and England, where there is data collection on every level in a highly commercialized agricultural sector, estimates for other commodities are much more difficult. For example, how does one decide upon the amount of meat slaughtered by local butchers and by individual farmers? And balance sheet estimation is even less reliable for milk, eggs, vegetables and fruits. The two major problems appear to be obtaining satisfactory independent reports and checks on the volume of production and arriving at a reasonable approximation of loss and waste up to the "retail level."

In underdeveloped countries that have collected little if any of the data needed for the construction of food balances, the margin of error involved in arriving at any one of these elements is great. Often production figures are incomplete with some districts not reporting, with others reporting only commodity marketings, or with farmers underreporting in hopes of minimizing taxes. Many developing countries have no independent official production data, and subsistence production crop estimates necessarily are derived by rough guesses about per capita consumption multiplied by equally unreliable population figures with some allowances made for non-food, waste, and other uses. The result is hardly reliable (9, pp. 184-193).

Of all the elements comprising the food balance sheet, trade data seem to be the most accurate since export and import commodities generally pass through official channels. Industrial "non-food" uses also may have a fair degree of reliability, as may processing and extracting rates for such foods as cereal grains and vegetable oils--but the reliability of such data must be evaluated for each country. Seed use is often a residual factor; and the quantities of food crops utilized for animal feed are very difficult to determine with any degree of accuracy. In many developing countries even the number of livestock are estimated to vary by several million head (cf. 10, p. 15).

And how to allow for waste and nutrient losses? It is important that these losses up to the retail level be distinguished from those incurred beyond the retail level. The amounts of such losses seem to vary from country to country, from commodity to commodity, and from year to year, especially as supplies are shorter or more plentiful. Unless these variations are taken into account, the estimated requirements plus "wastage allowance" may considerably misrepresent the actual food situation within a country. For example, to apply a uniform 15 percent waste allowance beyond the retail level both for those areas where hunger is thought to be widespread as well as for more affluent areas where surplus food stocks exist is clearly unrealistic (9, pp. 196-197).

With these reservations and limitations, one does not conclude that the national food supply and utilization estimates lack all general validity, but rather that they represent rough approximations as to the availability of food commodities. To the careful analyst they provide much useful information; to the unwary layman they may mislead and confuse. Therefore it is important that the object of these estimates be kept in mind and that sustained efforts be made to improve their reliability and usefulness. In the third section we will consider some suggestions which might be incorporated into food balance sheet estimates and which have been used in recent studies to provide a more reliable picture of food supply and utilization in specific countries.

B. Food Requirements Estimates: The Demand Side of the Equation

In an assessment of food requirements, calories become the acceptable measure of the quantity of food which is needed to meet the body's energy requirements. While no comparable unit is yet available to measure nutritional quality, protein content often is used as such an indicator because most foods rich in protein contain in sufficient amount those other nutrients essential for normal health and growth. Reference standards of each have been established to serve as guides for planning adequate nutrition for peoples in various parts of the world, and these standards allow for a sufficient margin of sufficiency above the average physical requirements of most individuals in the general population. In this section we wish to outline the method of determining the food requirements, as measured in calorie and protein allowances, which the FAO and USDA Surveys have employed[1].

1. Calorie Requirements

The science of nutrition has made significant progress in specifying those nutritional elements essential for the normal functioning of the human body. Special Nutritional Committees commissioned by the FAO have labored to precise the required calorie and protein allowances for the normal individual in different parts of the world (11, 13, 14, 18, 26).

The general approach taken by the FAO Commissions on Calorie Requirements has been to set requirements of a Reference Man and Reference Woman under well defined conditions and then to make adjustments for variations introduced by such factors as body size, age, activity, sex, pregnancy, and lactation. The Reference Man is assumed to be 25 years of age, weighs 65 kilograms, lives in a temperate zone with mean annual temperature of 10° C., is physically healthy, eats a nutritionally adequate diet, and spends 8 hours of his normal working day engaged in non-sedentary activities. The Reference Woman is of the same age, weighs 55 kilograms and lives in the same environmental conditions as her male counterpart. The Reference Man is assumed to require 3200 calories daily; the Reference Woman 2300. For those comparable to them, a range of energy expenditure between 2400 and 400 calories a day for men and between 1600 and 3000 for women appears to include most men and women (13, pp. 10-12; 11).

To assess the reliability of the recommended allowances, ittis necessary to consider each of the factors in turn. It is recognized that total energy expenditure is the sum of three components: (i) resting energy expenditure or the basal metabolic rate; (ii) energy expenditure related to the ingestion of food; and (iii) energy expenditure involved in physical activity. These three components are related to body size, and the Commission has derived a total energy requirement equation which relates calories required to nude body weight (kg.) as follows (13, pp. 17-19, 35):

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[1] Cf. Appendix for an illustration of this method applied in the context of a specific country.

Men:	$E = 815 + 36.6W$	W = nude weight in kg.
Women:	$E = 580 + 31.1W$	E = energy required in cal.

The FAO recommendations suggest that there exists a substantially linear relationship between age and calorie requirements of adults, with the basal metabolic rate (BMR) for the 65 year old adult about 20 percent less than that of the reference adult. For each decade beyond age 25, calorie requirements are accordingly adjusted downward by 3 percent of reference requirements (13, pp. 21-23).

Energy needs also appear to be affected by prolonged exposure to heat or cold. Adjustments are recommended for variations in climate and temperature on the basis of an increase of 3 percent for every 10°C. of mean annual external temperature below reference temperature of 10°C., and a decrease in calorie requirements by 5 percent for every 10°C. above the reference temperature. This adjustment is applied to all age groups except infants (13, pp. 24-26).

The activity component is the most significant item in determining the magnitude of energy requirements (13, p. 15, cf. pp. 53-59 for the method used in making adjustments). Approximately one-half of the total requirements (circa 1500 calories for the reference man, 1260 for the reference woman) are estimated to be used in maintaining the vital body processes, and energy expenditure studies indicate that energy requirements are related to the intensity of muscular work according to the following rough energy budget:

Very light activity	--	less than 2.5 calories per minute
Light activity	--	2.5 - 4.9 calories per minute
Moderate activity	--	5.0 - 7.4 calories per minute
Heavy activity	--	7.5 - 9.9 calories per minute
Very heavy activity	--	More than 10 calories per minute

Rest pauses are allowed for extended periods of very heavy work, so that the overall rate of energy expenditure is no more than 5 calories per minute. Thus an eight hour shift of very heavy activity would require 2400 calories of energy; sedentary workers on the same shift would expend 768 calories (1.6 cal./min.)

The energy expenditure of the reference man is calculated on the basis of the following schedule of activity throughout the day:

a.	8 hours of work, mostly standing, at an average rate of 2.5 calories per minute		1200
b.	8 hours of non-occupational activity:		
	1 hour washing, dressing, etc., at 3 cal./min.	180	
	$1\frac{1}{2}$ hrs. walking, at 5.3 cal./min.	480	
	4 hrs. sitting, at 1.54 cal./min.	370	
	$1\frac{1}{2}$ hrs. active recreation or domestic work at 5.2 cal./min.	470	1500
c.	8 hours of rest in bed at basal metabolic rate		500
	Total cal./day		3200

The assumption is made that the mean activity of the adult population is similar to that of the reference man and woman. In fact no simple procedure is available to measure energy expenditure over a wider population sample. More accurate estimates must know the energy expenditure of various activities and the time spent at each over extended periods of time. In recent years, considerable refinements have been made in such studies, but very few studies have been undertaken relating levels of activity and calorie requirements among rural people in the underdeveloped countries. Until much more knowledge is available concerning the energy expenditures of peasant agriculturalists, the activity component of total energy requirements remains more a conjecture than a matter of fact (7; 30, pp. 10-13).

Further adjustments must be made when considering the food requirements for a national population (13, pp. 35-48). Assumptions must be made as to the number of pregnant and lactating women, and allowances made for additional energy requirements in each instance. In the absence of more precise data, the number of pregnancies are assumed to be 10 percent greater than the number of infants aged 0-12 months in any given year. The FAO Commission suggests an allowance of 40,000 per pregnancy. The lactation period is assumed to last for an average of 6 months, with an average daily milk production of 850 ml. The Commission recommends an allowance of 1000 cal./day for the period, on the assumption that the mother requires an additional 1000 calories from food if she is to provide milk with a caloric value of 600.

Infant requirements are calculated on the basis of kg. of body weight, with a yearly average of 110 cal./kg. Requirements of breast fed infants up to 6 months are included in those of lactating mothers. Children from

1 to 6 years have the following recommended allowances:

1-3	years inclusive		1300 cal.
4-6	years		1700 cal.
7-9	years		2100 cal.
10-12	years		2500 cal.
13-15	years	Boys:	3100 cal.
		Girls:	2600 cal.
16-19	years	Males:	3600 cal.
		Females:	2400 cal.

In the adolescent age group, 16-19, the calorie requirements assume weights of 60 kg. (male) and 50 kg. (female). If the average body size differs, the adjustment is made on the basis of the reference adult, which places the male requirement for this age group at 113 percent of the reference male and the corresponding female requirement at 104 percent of the reference woman. The same adjustments are made for environmental temperature for children over one year as for adults. When pregnancy and lactation adjustments are to be made, they are calculated in the same manner as for adults (13, pp. 27-34).

The FAO Commission on Calorie Requirements has revised the recommended daily allowances in the light of recent research findings, but the major shortcomings of this method lie not so much in the estimates of individual requirements, with the possible exception of the activity component, as in the problems incurred in aggregation when the statistical base is so inadequate. Often the population figures in underdeveloped areas are far from satisfactory and provide little information as to the sex and age profile of the country. But even when population estimates are improved, other difficulties remain that influence the calorie requirements as adjusted according to variations in the factors considered above (cf. McArthur, 25. The following discussion is based on this article).

a. Body weight: even if the formulae above are reliable, the lack of data on mean body weights in most countries presents a source of considerable error. For example, the Committee estimated that an error of 5 kg. in the weight used for men would account for a difference of over 100 calories in the estimated per capita requirement.

b. Age of adults: the validity of combining a decrease in metabolic activity with age and assuming changes in physical activity with advancing age for all population groups is questionable. There seems to be little evidence at a national level to justify this either way.

c. Climate and environmental temperature: the Commission assumed an inverse relationship between the mean annual temperature and the BMR. The same studies indicated a direct relationship between the BMR and relative humidity, but no allowance or adjustment was made for this.

d. Activity levels: the possibility exists that in some areas the normal food supplies do not permit an increase in physical activity beyond the level which is now preferred. In the absence of more adequate studies on activity levels of different occupational groups, the mean activity of the adult population has been assumed to be similar to that of the reference man and woman as outlined above. This critical assumption hardly seems reasonable, and it is very likely that a wide margin of error enters into the food requirement calculations because of the importance of the activity component in determining energy expenditure.

e. Pregnancy and lactation requirements: each of the assumptions here is a possible source of error. Infant mortality varies widely among and within different countries and regions; and lactation may continue up to two years in some areas, although the milk yield tends to decline considerably by the end of that time.

f. Requirements of children: studies in diet adequate countries suggest that children are growing more rapidly and the average size of the adult population is increasing. The same may hold in the future for the developing countries if they change from diet deficient to diet adequate areas, although the figures do not allow for adequate comparisons between the two groups.

One conclusion to be drawn from the above remarks is that the FAO calorie requirement scale is tentative and uncertain for most underdeveloped countries. Available evidence does not allow an accurate assessment, even on a per capita basis, of the magnitude of the existing food deficiencies in order to estimate future food requirements. Thus any figures on the number of people in various countries who are undernourished are most tenuous. Again, the careful analyst recognizes the limitations of the FAO appraoch and the tentative nature of the conclusions. This is a first and most important step to a more accurate portrayal of the nature of the world food problem.

2. Protein Requirements

As has been noted above, the protein content of a diet often is used as an indicator of nutritional quality because most foods rich in protein also contain adequate amounts of essential nutrients. In its own right, protein is needed to provide nitrogen and certain amino acids for synthesis of body proteins and other nitrogen-containing substances. Body proteins contain some 20 amino acids and those which cannot be synthesized by the body must be provided by dietary protein (26, p. 15).

Protein deficiency occurs at all ages, but its impact is most felt and its incidence is greatest in infancy and early childhood. Stunted growth, respiratory and gastrointestinal diseases, weanling diarrhea, mental retardation--such are the known effects of protein deficiency, the major nutritional problem in the world today (18, pp. 7-8). There are two basic approaches to the estimation of protein requirements: (i) observation of the minimum intake required to support normal growth and health and to maintain a nitrogen equilibrium in a normal person; and (ii) nitrogen requirement method which estimates the nitrogen utilized or lost through body elimination processes (urine, faeces, perspiration, etc.) and growth, pregnancy, lactation, and normal anxieties. Reference protein is derived as a multiple (6.25) of the estimated nitrogen requirement and is expressed as grams per kg. body weight per day. The average adult requires 0.59 grams of reference protein (net utilization by definition is 100 percent). An allowance of plus and minus 20 percent provides an upper limit (0.71 gm.), which is expected to cover the requirements of all but a very small proportion of the population, and a lower limit (0.47 gm.), below which protein deficiency may be expected to occur in all but a very few individuals (18, pp. 19-22).

Based on the upper level, the FAO reference man requires 46.15 gms. of reference protein daily. A further correction factor is involved at this point, viz., the net protein utilization (NPU), which is an index of protein quality of particular food commodities (18, pp. 42-45). The FAO Commission suggests that an NPU value of 60 to 70 percent is appropriate for developing countries. If the NPU equals 65 percent, 71 gms. of protein are required for the reference man daily. A diet that provides less than 5 percent of the calories in the form of utilizable protein is incapable of meeting the needs of the average adult, even when consumed at a level that meets the calorie requirements.

The influence of age and climate upon protein requirements is indeterminate. Allowances are made for pregnancy by the addition of 10 gms. protein per person per day and for lactation by 15 gms. protein per person per day, but no allowance has been recommended for variations in activity levels (18, pp. 24-26, 52-53).

Some revisions in the recommended protein allowances have been suggested by the FAO Commission on Protein Requirements; but even if the basic formulae for calculating individual requirements are reliable, how are aggregative protein requirement figures to be drawn up in the light of inadequate statistical information? Some of the weaknesses involved in estimating calorie requirements are also apparent here. What is the effect on nitrogen requirements of a young population, characteristic of most developing countries? How arrive at a reliable mean body weight for most countries? What impact does weather have on the NPU value, and how does the NPU vary from season to season? Whether one takes the upper or lower limit, i.e., 70 or 60 percent NPU, makes a great difference in estimating aggregate protein requirements for groups of individuals and for a national population.

It seems that two conclusions must be drawn: (i) the available evidence does not allow precise assessment of the magnitude of the protein deficiency which exists; and (ii) any estimates of the number of people in the world who are malnourished are tentative and subject to a wide margin of error. On the other hand, there is sufficient evidence to establish beyond doubt that malnourishment is widespread in many parts of the world. Serious efforts are underway in many quarters to specify the incidence of protein deficiency more exactly and to increase the production of protein foods to meet these needs. In the following section, some of the current approaches which promise to improve our understanding of the nature and scope of the world food problem will be discussed.

III. New Approaches to Understanding the World Food Problem

The nature and magnitude of the world food problem largely has been defined by the pioneer survey studies of the FAO. Unfortunately, conclusions presented as rough approximations too often have been quoted as exact figures, with the result that statements based on the survey reports sometimes conceal or misrepresent as much as they illuminate. Within the urgencies of producing more food for rapidly growing populations, these points may be trivial; nevertheless such deficiencies as exist must be noted and new research efforts undertaken to provide policy makers with a sound base for national development planning if the essential needs of their burgeoning populations are to be met.

Crucial to improving the quantification and understanding of the world food problem is the collection of statistical information. With the encouragement and support of the United Nations, significant improvement has been made in statistical reporting systems in nearly every country over the past two decades. Population censuses now exist for most countries. Household budget surveys, nutritional diet studies, agricultural production and utilization surveys, marketing studies, and other basic surveys have been expanded or introduced in many countries (12, 15, 17, 31). Many large gaps remain, however, and even in those countries with the most highly developed statistical reporting systems there are many difficult questions that must be resolved in calculating such figures as production and utilization components of the food balance sheet.

In spite of these basic difficulties, it is possible for a careful and thorough research team to build up a reliable picture of a country's food economy by a painstaking collection of existing information and by a diligent checking and cross-checking and corroboration of this information with other independent data sources. A careful study of this type need not entail the creation of new statistical or analytical tools, but can utilize the basic approach of the FAO and U.S.D.A. studies. The three major tools employed are: (i) regional and national food balance sheets; (ii) consumption surveys and other indices of utilization to estimate aggregate consumption; and (iii) nutritional standards, such as calorie and protein allowances, to test the consistency of the results (30, 32).

The method and limitations of each of these has already been indicated, but little has been stated about improving the usefulness of these tools. The food balance sheets might be applied to the improvement of national food production and utilization, to the measurement of changes over time in the pattern of national food consumption, or to the estimation of changes in the contribution of the agricultural sector to the gross national product of individual countries. To be useful for such purposes, however, it is important that food balance and consumption estimates explicitate more fully the method employed in their calculation and that they provide as much information as possible to their users, e.g., origin, coverage, quality of data, etc. Adjustments and the assumptions involved should be indicated, and adjustments or "judgment approximations" ought to be expressed in terms of probability ranges rather than in simple figures (9, pp. 198-199).

To assess adequacy of diets and of national supplies by estimating the nutritional requirements of a population from certain reference standards is also open to serious question. Nutritional deficiencies of a country and of population groups within a country must be demonstrated by observation of the people concerned. Unfortunately such information is lacking in many countries.

The principal means of obtaining data on dietary adequacy at the household level is the food consumption survey. By weighing the food items prepared for the household menu or by interviewing the housewife for a twenty-four hour recall of the amount of specific food items eaten by members of the household, nutrition research teams can estimate the quantities of food ingested in sufficient detail to calculate the nutritive value of the diet (22). When clinical examinations and biochemical data of nutritional levels of individuals are combined with food consumption surveys, the results are known as Nutrition Surveys (17, p. 10).

In many countries food consumption surveys and nutrition surveys exist only for small samples of the population. Their usefulness in establishing national food requirements depends upon the scope of the survey, which in turn depends upon the purpose for which the survey is conducted, i.e., nutrition, cost of living, income and demand analysis, etc. Where such surveys exist, they can serve as a cross-check on the reliability of food supplies derived from balance sheet data.

Research studies in recent years have concentrated on bringing together these estimates of food supply and food consumption within a single, comprehensive consolidated account where they are carefully compared and subjected to consistency tests (30). Supply estimates are derived from the food balance sheet. Demand or consumption estimates are built up from consumption and nutrition surveys, household budget surveys, combined marketing and road check surveys, and other sample surveys conducted on a "micro" level (31). It is important that these estimates be independently arrived at if they are to serve as reliable cross-checks against each other. When acceptable conversion factors are applied to both supply and consumption data, comparison of the aggregate estimates may be made in terms of a few common denominators such as calories or grams of protein.

In the preparation of the consolidated account, recommended nutritional allowances or norms are considered as upper and lower values within which the estimates may be expected to fall. Judgment intervals around the final estimates indicate their reliability in much the same manner as confidence intervals indicate the reliability of statistical data. The probable range of error of these final estimates is as important as the figures themselves in the proper evaluation of a nation's food balance sheet.

The final step in this consolidated approach is the derivation of a new estimate of domestic food production by putting the balance sheet process in reverse. Although these new production estimates include a transferred error, they appear more satisfactory than the original production figures because they are now consistent with established aggregate supply and utilization figures and are bounded by reliable confidence intervals. The result is a flexible but workable approach to the analysis of food supply and consumption data in the context of developing countries where such information is less than adequate.

The merit of this approach for the study of the food economies of the developing countries is evident in several studies undertaken at Cornell University and Stanford University (6, 24, 29, 32, 33). Especially worthy of note is Malcolm J. Purvis' detailed analysis of the food economy of Malaysia (32). From a thorough evaluation of available statistical data, Purvis constructs a balance sheet of net food supplies and an overall picture of national food consumption patterns. To illustrate both the potentialities of this approach and its creative adaptation in a specific context, we shall sketch briefly the method followed by Purvis in his study.

After a background sketch of Malaysia, its peoples and economy (32, pp. 13-61), Purvis proceeds to evaluate the principle information available for the construction of food supply estimates: data on production, trade, and the utilization of food commodities. For each of Malaysia's four principle regions, he examined in detail the data sources and the manner in which such data were compiled. As is evident, the "objectivity" of numbers in official statistical bulletins is often illusory. Partial surveys of production data, manufacturing returns, census figures--each was compared against other available sources of information, until some feel for the likely range in which actual production lies was obtained (32, pp. 62-143).

By such a process of "guided guesswork," which relies heavily upon a knowledge of production conditions in the region under consideration, the missing links in the preliminary production estimates were filled in wherever possible. On the basis of numerous assumptions, carefully explicitated, and "best" informed guesses, more complete estimates of production were compiled. Although subject to wide margins of error, these estimates served as useful starting points and provided estimates which cannot be dismissed as valueless (32, p. 117).

Trade data on imported commodities generally were considered reliable, although smuggling in some regions perhaps understated even these data. Accordingly trade statistics also were checked for accuracy and consistency depending upon the local conditions.

Purvis was confronted with a problem of major proportions in the adjustment of gross supplies to a net supply basis, since much of the information on seed, wastage, feed, manufacturing use, and extraction rates was limited or not available for Malaysia. Yet this problem was thought to be minimized somewhat because the most important adjustments to gross supplies were those relating to the extraction of milled rice from padi and the use of imported feed grains for animal feeds.

Once aggregate net food supplies are estimated, they are converted to daily per capita supplies and, by the application of appropriate conversion factors, to per capita supplies of proteins and calories. The reliability of these conversions and the subsequent comparison of per capita supply levels depends upon the accuracy of the population data. Thus trustworthy population figures become a crucial element in the integration of the supply and demand approaches.

In the instance of Malaysia, the population figures were conceded to be fairly accurate. With careful selection of conversion factors, Purvis concluded that the margin of error in estimating per capita supplies of calories and protein could be approximated with considerable accuracy (32, pp. 131-137).

In the second stage of the analysis, the demand approach, an attempt was made to obtain an independent estimate of food availability from consumption data. The all important checking with the supply approach in the consolidated account depends upon the information gathered here (32, pp. 144-189).

Purvis illustrates how existing sample survey data, often not directly concerned with food consumption, can be used in the demand approach analysis. The two major sources of such data in Malaysia were the large scale Household Budget Surveys (HBS) and small nutrition surveys. As with any survey, the confidence with which the findings may be used depends upon the "representativeness" of the sample and the accuracy of the sample methods and findings, i.e., the "internal reliability."

Accordingly, Purvis examined in detail such questions as the methods by which the samples were drawn, how the data were collected, the comparison of characteristics of the sample with those of the population it purportedly represented, and an evaluation of the reliability of the data. In addition he applied a number of checks on the internal consistency of the data such as the pattern of food expenditure in relation to behavior between the different income groups of the sample.

In Purvis' judgment the Malaysian HBS passed the tests on each count--it appeared carefully conducted, had a reasonably representative sample and obtained consistent results. Use of the data, however, necessitated making several further adjustments such as reweighting the sample to reflect national population characteristics, conversion of monetary expenditures to physical quantities and the adjustment for sundry items of expenditure (32, pp. 156-161).

Several other small scale surveys provided limited information on food consumption. Although much of this information was of limited reliability, in many instances it filled in the picture of local sub-groups in terms of dietary habits and consumption levels (32, pp. 179-189).

The third and final stage in the analysis of food supply data was the consolidated account, which attempted to integrate the production and consumption data, independently arrived at through the supply and demand approaches, into a "best" figure to which some reasonable estimate of error might be ascribed. Basically this third stage involved reconciling food supplies estimates with food consumption estimates (32, pp. 190-219).

The first step in this consolidation was the comparison of the overall food consumption patterns provided by the two approaches. Aggregate supplies of calories and proteins were compared with levels of food availability between regions, commodity groups, and data sources. Levels of nutrient intake were compared with levels anticipated on the basis of nutritional surveys and standards. Purvis found that the estimates of total food supplies and estimates by commodity groups were of the right order of magnitude and that the data from the two approaches allowed for the construction of a consolidated food account with some precision (32, p. 194).

The second step in the consolidation account involved the comparison of estimates of supplies for individual commodities. Rank correlation tests were used. If the two estimates were sufficiently close, this provided mutual corroboration of their reliability, and a simple average of the figures was considered adequate.

Perhaps even more important for the researcher was the detailed knowledge of the strengths and weaknesses of the data which emerged from such an analysis. This greatly assisted him in forming a judgment between the figures obtained from the two approaches. Only after such a careful appraisal could a subjective evaluation be made as to the probable range of error contained in each of the figures.

The final results which emerged were thought to be reasonable estimates of current food production and supplies in Malaysia. In the second half of his study Purvis used these estimates as the basis for an extensive analysis of the future food needs of the country, and the implications of these requirements in terms of public policies and the allocation of resources to increasing agricultural productivity where food supplies were foreseen as inadequate to meet demand.

Other studies on the food economies of Ceylon, Ghana, and Mauritius have employed this same general approach (24, 29, 33). Obvious adoptations were made for local situations, but the success of the method so ingeniously followed by Purvis indicates that underdeveloped statistics can be made to yield a reliable picture of a nation's food situation.

Many of the problems involved in specifying individual food requirements await better medical evidence and improved statistical information. Until such evidence if forthcoming, generalizations often are more opinion than fact. One particularly important area which merits attention is the relationship of activity levels to energy expenditure (7, 30). The assumption has been that the average activity patterns of the population are similar to those of the reference adult, but little evidence exists to justify such an assumption in tropical areas where the majority of the population are peasant agriculturalists. Since the activity level is the principal component of energy expenditure, research in this area promises to shed light on several important related questions. Are low productivity figures in some areas the result of work levels conditioned by low calorie intake of food? Would physical activity levels be increased if normal food supplies were increased?

Energy requirements and activity levels have been correlated in some industrial workers, but little effort has been made to undertake similar studies among rural peoples. Telemetry studies promise important breakthroughs in this area, and improved transmission and recording equipment may allow energy expenditure studies to be conducted among rural workers with relative ease (28).

IV. Conclusion

Recent developments appear to have shifted the nature of the world food problem (1, 37, 38). The "green revolution" has begun to ease the food supply inadequacies in many countries, especially in India and Pakistan (5, 27, pp. 32-36). The question of continued hunger and malnutrition, however, will be closely tied to the distribution of the benefits of these new breakthroughs in agricultural productivity. Large expenditures of public funds will be needed to carry out the potential for agricultural and economic development, and to solve the new problems which follow upon increased production.

The most important barrier to realizing this potential development is the question of effective demand (36, pp. 17-22; 38). If large numbers of people are unemployed and poor and have no access to the benefits of increased agricultural productivity, hunger and malnutrition will remain widespread. The statement of P. V. Sukhatme, the Second Director General of FAO, unfortunately remains all too true: "The privileged and the well-to-do everywhere will eat all they need and perhaps more." (34).

At this point, the nature of the food problem is closely related to the reform of basic economic and social institutions as well as to the problems of unemployment and urbanization (2; 23; 37; 27, pp. 58-64). These problems, combined with the rapid population growth throughout the developing world, may well prove to be more difficult of solution than the world food problem as it has so far been defined.

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TABLE I

DAILY CALORIE REQUIREMENTS IN UGANDA[1/]

(Adult weights: male, 57.5 kg.; female, 50 kg.; Environmental temperature, 20°C.)[2/]

Age Group	Sex	Reference Requirements (Calories)	Adjusted for Body Weight and Activity[3/] (Calories)	Adjusted for Temperature (Calories)	Population[4/]	Daily Requirement (Calories)
0 - 1		1,120		1,120	226,800	254,016,000
1 - 4		1,362		1,294	907,200	1,173,658,000
0 - 4		1,314			(1,134,000)	
5 - 9		1,970		1,872	885,000	1,656,720,000
10 - 12		2,500		2,375	414,600	984,675,000
13 - 14	M	3,025		2,874	139,600	401,210,400
	F	2,625		2,494	136,800	341,179,200
15 - 19	M	3,530	3,074	2,920	286,000	835,120,000
	F	2,430	2,481	2,357	298,000	702,386,000
20 - 29	M	3,200	2,720	2,585	524,000	1,354,540,000
	F	3,040	2,386	2,270	582,000	1,321,140,000
30 - 39	M	3,104	2,638	2,506	442,000	1,107,652,000
	F	2,231	2,314	2,198	452,000	993,496,000
40 - 49	M	3,008	2,557	2,430	331,000	804,330,000
	F	2,162	2,243	2,130	302,000	643,260,000
50 - 59	M	2,768	2,353	2,235	197,000	440,295,000
	F	1,990	2,064	1,960	165,000	323,400,000
60 - 69	M	2,528	2,149	2,042	96,000	196,032,000
	F	1,817	1,885	1,790	81,000	144,990,000
70+	M	2,208	1,879	1,785	40,000	71,400,000
	F	1,587	1,646	1,564	32,000	50,048,000
TOTAL					6,538,000	13,799,547,600

Average Requirement per caput per day 2,110 calories

TABLE II

PROTEIN REQUIREMENTS IN UGANDA 1/

(Adult weights: male, 57.5 kg.; female, 50 kg.)

Age Group		Population	Average Body Weight 2/ (kg.)	Daily Requirement per Kilogram Body Weight 3/	Requirement per Person per Day	Total Daily Requirement (gm.)
Infants 0-1 yr. non breast fed		226,800	9	1.70	15.30	3,470,040
Children,						
1 - 3 yrs.		680,400	13.5	1.06	14.31	9,736,524
4 - 6 yrs.		580,800	18	0.97	17.96	10,140,768
7 - 9 yrs.		531,000	27	0.92	24.84	13,190,040
10 - 12 yrs.		414,600	35	0.86	30.10	12,479,460
13 - 14 yrs.	M	139,600	49	0.84	41.16	5,745,936
	F	136,800	47	0.77	36.19	4,950,792
15 - 19 yrs.	M	286,000	56	0.84	47.04	13,453,440
	F	298,000	50	0.77	38.50	11,473,000
Adults	M	1,630,000	57.5	0.71	40.83	66,552,900
	F	1,614,000	50	0.71	35.50	57,297,000
Allowance for Pregnancy 4/		(249,800)			6	749,400
Allowance for Lactation 5/		(170,000)			15	2,550,000
TOTAL		6,538,000				211,789,300

$$\text{Requirement for Reference Protein} = \frac{211,789,300}{6,538,000} = 32.39 \text{ gm. per caput per day.}$$

$$\text{Requirement for protein of NPU 60} = \frac{32.39 \times 100}{60} = 54 \text{ gm. per caput per day.}$$

FOOTNOTES

Footnotes to Table I

1/ Method of calculating requirements is outlined in FAO, Calorie Requirements (Nutritional Studies No. 15, Rome, 1957), pp. 35-46.

2/ Assumed mean temperature for Uganda is 20°C. Cf. Uganda Department Lands and Surveys, Atlas of Uganda (1962). Body weights for reference adults average based on a series of weighings undertaken at Mulago Hospital in 1957. Cf. J.B. Cleave, "Food Consumption in Uganda," East African Journal of Rural Development, January 1968, p. 71.

3/ The daily activity schedule used here is that proposed by Cleave, Ibid., pp. 72-73.

4/ Population data is based on 1959 Census, UN Demographic Yearbook: 1968, pp. 130-131.

Footnotes to Table II

1/ Method of calculating requirements is outlined in WHO/FAO, Protein Requirements (WHO Technical Report No. 301, Geneva, 1965), pp. 20-27, 48-55. Population data and specifications of reference adults are from those sources used in Calorie requirements (see Footnotes to Table I above).

2/ WHO/FAO, Protein Requirements, pp. 20, 51.

3/ Ibid., pp. 22, 51.

4/ Ibid., pp. 24-26, 52-53. Formula: $226{,}800 \times 110\% = \frac{249{,}800 \times 6}{2}$

$= 749{,}400$ Calories.

5/ Loc. Cit., Assume infants are breast fed for eight months. Formula:

$$\frac{226{,}800 \times 8}{12} = 170{,}000 \times 15 = 2{,}550{,}000 \text{ Calories.}$$