APPENDIX 3

Methodology for assessing food inadequacy in developing countries

This appendix deals with the conceptual issues concerning the assessment of food adequacy and with the operational procedures employed in estimating the extent of food inadequacy in a population. The assessment of food inadequacy at the national level has often been undertaken by comparing the average per caput dietary energy supply (DES) figure taken from a country's food balance sheet with an estimate of the average per caput energy requirement. This approach provides a measure of inadequacy based on the assumption that the available food is distributed in proportion to individual requirements within the population, i.e. the distribution is equitable. This assumption is not supported by empirical evidence, the primary causes being national socio-economic factors. In most developing countries, even if the total amount of food available for human consumption exceeds the aggregated individual requirements, a part of the population may still have an inadequate consumption level while another part has a more than adequate level. In view of this, the method of simply comparing the national per caput food availability with the average per caput requirement has long been discontinued. Instead, a methodology is used that assesses the proportion of the population that has inadequate access to food.

The methodology is essentially similar to that adopted in *The Fifth World Food Survey* but includes a number of improvements and additions. This appendix attempts to provide a comprehensive account of the procedures employed: section 1 describes the basic concepts and principles of energy requirements used in assessing the adequacy of intakes; section 2 discusses the need to deal with aggregated data and provides statistical measures of the prevalence and intensity of food inadequacy; section 3 deals with the statistical database and operational procedures used in the computation of estimates for the developing countries; and section 4 highlights the distinguishing features of the present approach compared with that of *The Fifth World Food Survey*.

1. BASIC CONCEPTS AND PRINCIPLES OF ENERGY REQUIREMENTS FOR ASSESSING ADEQUACY OF INTAKES

The estimation of the prevalence of food inadequacy is feasible within a distributional framework where the principles of energy requirements are used in conjunction with the distribution of food availability or supply of a given population. In this context, it is necessary to take account of the fact that energy requirements depend on several factors. At the level of the individual, it is a relatively straightforward procedure to include the effects of age, sex, body size and physical activity. Until recently, however, there has been controversy regarding certain influences that are not so well understood – notably, the possibility of the metabolic efficiency of energy utilization in an individual varying systematically in response to changes in energy intake. Since the time of *The Fifth World Food Survey* the consensus has been that, even if such intra-individual variation does occur, its magnitude is small in comparison with that of other sources of variation (James and Schofield, 1990). The approach adopted for the present survey, therefore, is not to make any correction for such an effect but to assume that, if any such variation exists, it was taken into account along with the random sources of variance, such as short-term day-to-day changes, by averaging over a suitably long time so as to correspond to the "habitual" concept.

The human body requires dietary energy intake for its energy expenditure, the principal components of which are: i) the basal metabolic rate (BMR), i.e. the energy expended for the functioning of the organism when the individual is in a state of complete rest; ii) the energy needed for digesting and metabolizing food and storing tissues during growth; iii) the energy expended in physical activities, both productive work and non-work (leisure) activities. Some additional energy is required by children to allow for physical growth and by pregnant and lactating women for the deposition of foetal tissue and the secretion of milk.

An individual is considered to be in a steady state or in a state of energy balance if his or her total energy intake equals his or her total energy expenditure. The concept of a steady state or state of energy balance is notional – no one is ever in an absolutely steady state (FAO/WHO/UNU, 1985, p. 20).

However, while on a day-to-day basis there is often no fine matching between intake and expenditure, over a longer period an individual is (on average) expected to achieve an energy balance (James and Schofield, 1990, p. 39). In view of this, energy requirements are based on either the energy expenditures or the energy intakes of reference groups consisting of *healthy, active and well-nourished individuals*.

Earlier assessments of human energy requirements were based on the intakes of a reference group or population. However, the Joint FAO/WHO/UNU Expert Consultation on Energy and Protein Requirements, which met in 1981 (FAO/WHO/UNU, 1985), recommended the expenditure approach for adults and adolescents. Thus, it defined energy requirement as follows:

> "The energy requirement of an individual is the level of energy intake from food that will balance energy expenditure when the individual has a body size and composition, and level of physical activity, consistent with long-term good health; and that will allow for the maintenance of economically necessary and socially desirable physical activity. In children and pregnant or lactating women the energy requirement includes the energy needs associated with the deposition of tissues or the secretion of milk at rates consistent with good health."

Energy requirement is therefore defined as a function of two basic variables: physical health as expressed by body size (weight) and physical activity. The FAO/WHO/UNU report also recognized the existence of a *range of body weights* that are consistent with healthy individuals in any age-sex group. Similarly, there is a *range of physical activity levels* that may be considered to be economically necessary and socially as well as physiologically desirable. It therefore follows that there is a *range of energy requirements for individuals* in any given age-sex group.

The existence of this range creates a problem in identifying all the individuals whose energy intake may be deemed inadequate. Consider the group of individuals whose (habitual) intake lies within the range of energy requirements. While for the group as a whole the range of intakes and requirements coincide, and the average intake may also coincide with the average requirement, the intake of any particular individual may still fall short of his or her own requirements. In general, therefore, unless each person's ideal body size and physical activity level are known (which is seldom the case) so that his or her respective requirements within the range can be specified, it is not possible to know the true food adequacy status of individuals.

However, the problem is made more tractable by the capacity of individuals to adjust their intake in line with their requirements.

> "Most people have the ability to select their food intake in accordance with their energy requirement over the long-term, since it is believed that regulatory mechanisms operate to maintain a balance between energy intake and energy requirement over long periods of time" (FAO/WHO/UNU, 1985, p. 17-19).

This regulatory mechanism means it is safe to expect that, if there were no constraints in the choice of intake, the individuals with an intake falling within the range of requirements would tend to consume according to their needs and, as a result, they would all be meeting their respective requirements. In fact, the report's recommendation to take the average of the range of requirements as the average intake norm for the group as a whole is based precisely on this expectation. Thus it argues:

> "This implies that one would expect there to be a correlation between energy intake and energy requirement among individuals if sufficient food is available in the absence of interfering factors .... If self-selection is allowed to operate, it is to be expected that individuals will make selections according to energy need and the probability of inadequacy or excess will be low across the whole range [of requirements] .... If the average energy intake of a class were equal to the average

> requirement of the class, almost all individuals would be at low risk because of processes regulating energy balance and the resultant correlation between intake and requirement" (FAO/WHO/UNU, 1985, p. 19).

Of course, in reality people do face constraints in meeting their requirements – otherwise the problem of food inadequacy would not exist! However, the argument made here is that, as the intake of this group is high enough to fall within a range of intakes associated with healthy and active individuals, it is reasonable to expect that the individuals within the group would be free enough to choose an intake according to their respective requirements[1] (i.e. the probability of intakes being close to requirements is high). As stated earlier, this expectation may not hold true in reality so some members may still be under some degree of constraint, but the essential point is that, on the whole, the group can be considered to be free enough to bring intakes close to requirements. As a result, these individuals can be said to be at a low risk of food inadequacy (or excess).

However, the same argument cannot be made for individuals whose intake falls below the range of requirements. The regulatory mechanism of adjusting intakes to requirements may still work to some extent but, since their intake is below the range of requirements, the capacity of these individuals to meet their requirements must evidently be considered to be hampered by constraints on food consumption. Therefore, such individuals must be considered to be at a high risk of food inadequacy. On the other hand, individuals whose intake lies above the range of requirements are also at a high risk – although in their case the risk is that of suffering from the harmful consequences of an excess intake (i.e. obesity).

It follows from the above that the range of requirements can be considered as a range of acceptable intakes. As a consequence, the entire population in a given age-sex group can be divided into three classes: i) individuals whose intake falls below the range of requirements and should therefore be considered to be at a high risk of food inadequacy; ii) individuals whose intake lies above the range of requirements and should therefore be considered to be at a high risk of excess; and iii) individuals whose intake falls within the range of requirements and can be therefore said to be at a low risk of both food inadequacy and food excess. The idea is expressed in Figure 1 which shows the probability of inadequacy and excess for intakes falling within and outside the range of energy requirements defined by y_l and y_h.

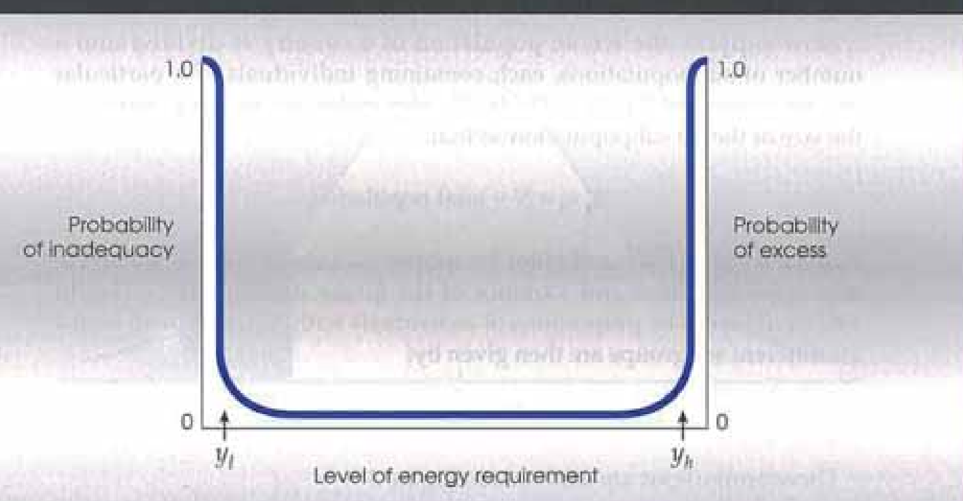
[1] This implies that the variation in intake is systematically related to the variation in requirement, thus leading to the expectation of a high positive correlation between intake and requirement for the group of individuals with intakes falling within the range of requirements.

For intakes ranging between y_l and y_h, the probability or risk of either inadequacy or excess is low – low enough to be "acceptable". Thus, individuals with an intake within this range can be considered to have adequate food. As the individuals whose intake falls below y_l are at an unacceptably high risk of food inadequacy, they are the ones to be captured in an assessment of food inadequacy. Accordingly, the lower limit of the range of requirements, y_l, is accepted as the minimum dietary energy requirement or the cutoff point for identifying the set of people with inadequate access to food. This is the basic principle underlying the assessment of the prevalence of food inadequacy in this survey.

An exception to the above principle has been made with regard to children in age groups below ten years. Their cutoff points have not been set at the lower limit of the range of requirements but at a level that is close to the average requirement (μ_y). Recall that the justification for adopting the lower limit lies in the expectation that, within the range of requirements, individual intakes are likely to be in close proximity of requirements. However, this expectation is more likely to exist among those individuals who have the ability to choose their intakes than among those whose choices are made for them by others within the consumption unit (e.g. household). Since children usually belong to the latter category, their risk of inadequacy or excess within the y_l and y_h range is not likely to be low. As a result, the use of the minimum value of the range of requirements as the cutoff point may lead to a serious underestimation of underfed children. The scope for such underestimation is reduced by using a cutoff point that is close to but below the average requirement.

FIGURE 1

PROBABILITY OF FOOD INADEQUACY AND EXCESS



2. ASSESSMENT OF FOOD INADEQUACY AT THE NATIONAL LEVEL

This section explains the procedures for calculating the various measures of food inadequacy. First, however, it is necessary to address an issue of aggregation that is determined by the nature of the data available.

The need for an aggregated distribution framework

It may be recalled that the cutoff point for identifying inadequately fed individuals is specified in the first instance for each age-sex group. If intake distribution data were available for each such group, the prevalence of food inadequacy could be estimated separately for each group and then added up to obtain a national estimate. In reality, however, nationally representative data sets on such age- and sex-specific intake distributions are not available. The information available is at best close to an aggregated distribution framework, i.e. the distribution of intake averaged over the different age-sex groups. As a consequence, a weighted average of the group-specific cutoff points must be applied. The link between this aggregated approach (applying a single cutoff point to a single intake distribution) and the disaggregated approach (first estimating the prevalence for each age-sex group separately and then building up the national estimate) is discussed below, as is the unit of analysis and classification in the aggregated distribution framework.

The disaggregated distribution framework. First, consider the case where the individual intake distribution for a particular age-sex group is known. If y_l represents the cutoff point below which the intakes of individuals of the given age-sex group are considered to be inadequate, the proportion of the population with an inadequate intake is represented by P_u, the shaded area in Figure 2. Provided the necessary data are available, the computation of P_u is fairly straightforward.

Now suppose the whole population of a country is divided into a number of subpopulations, each containing individuals of a particular age-sex group. Let Ω_1, Ω_2 ... Ω_M be M subpopulations and let n_j represent the size of the jth subpopulation so that:

$$\sum_{j=1} n_j = N = \text{total population}$$

Further, let y_{lj} be the cutoff point for subpopulations $j = 1, 2 \ldots M$ and let μ_j and σ_j^2 be the mean and variance of the intake distribution of the jth subpopulation. The proportions of individuals with an inadequate intake for different subgroups are then given by:

$$(P_{u1}); (P_{u2}); \ldots \text{ and } (P_{uM})$$

These proportions are as shown in Figure 3.

The number of individuals with an inadequate intake in the whole population is given by:

$$N_u = P_{u1}\, n_1 + P_{u2}\, n_2 + ... + P_{uM}\, n_M$$

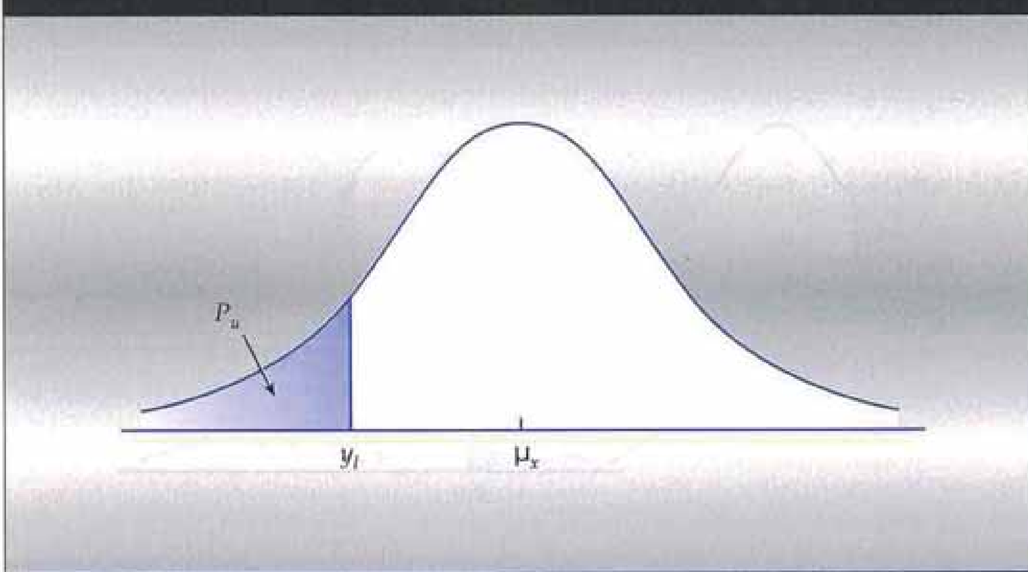
and the overall proportion of the population with an inadequate intake, i.e. N_u/N, can be expressed as the average of the respective subgroups' proportions, P_{uj}, with the respective population shares, n_j/N where j = 1, 2 ... M, as weights. Thus, if the weighted average of one single individual from each of the M subgroups is defined as a hypothetical "average individual", N_u/N can also be regarded as reflecting the proportion of underfed in a population composed of these "average individuals". This principle is utilized in the aggregated distribution approach.

The aggregated distribution framework. Suppose that the population is divided into M subpopulations corresponding to different age-sex groups, with the symbols n_j and μ_{yj} denoting, respectively, the population size and the average energy requirement for group j. If $W_j = n_j/N$, the aggregated average energy requirement can be represented by:

$$\mu_y^* = \sum_{j=1}^{M} \mu_{yj} \,.\, W_j$$

FIGURE 2

PROPORTION OF POPULATION WITH AN INADEQUATE INTAKE, BASED ON KNOWN INTAKE DISTRIBUTION FOR A GIVEN AGE-SEX GROUP



which is a weighted sum of the average energy requirements corresponding to the different age-sex groups. This is what is generally referred to as the average "per caput" requirement of a population. The aggregated cutoff point, which is derived as

$$y_1^* = \sum_{j=1}^{M} y_{1j} W_j$$

can similarly be referred to as the minimum per caput energy requirement. As both of these measures refer to weighted averages over the different age-sex groups, they can also be seen as referring to the minimum and average energy requirements, respectively, of the hypothetical average individual. The aggregated intake distribution can be formulated by considering the intakes of the subpopulations. Let X_1, X_2 ... X_M represent the intakes of the M subpopulations. The variable representing the aggregated intake is then given by:

$$X^* = \sum_{j=1}^{M} X_j W_j$$

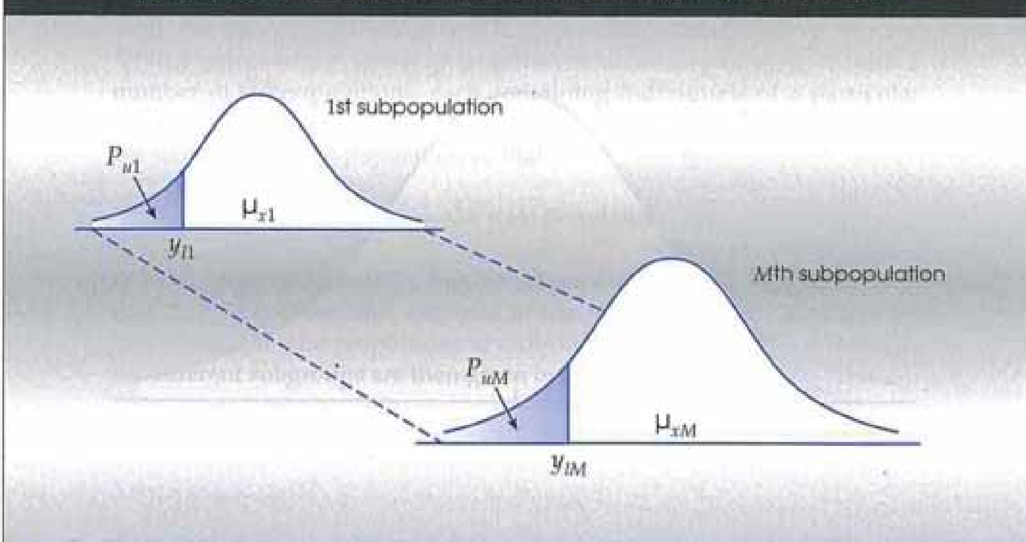
and its mean and variance can be expressed as follows:

$$\mu_x^* = \sum_{j=1}^{M} W_j \mu_{xj}$$

$$\sigma_x^{*^2} = \sum_{j=1}^{M} W_j^2 \sigma_{xj}^2 + 2\sum_{j=1}^{M} \sum_{k>j}^{M} W_j W_k \, cov(X_j, X_k)$$

FIGURE 3

PROPORTIONS OF DIFFERENT SUBGROUPS WITH AN INADEQUATE INTAKE



The aggregated intake distribution $f(x^*)$ is not actually known. However, as will be discussed in section 3, it is quite plausible to assume that the distribution is log-normal and can therefore be approximated on the basis of estimates of the mean, μ_x^*, and the variance σ_x^{*2}. Since μ_x^* is the weighted average of the group-specific average energy intake, it can be also expressed as:

$$\mu_x^* = \text{total energy intake/total population } (N)$$

which implies that it is given by the per caput DES figure from the food balance sheets. The estimation of σ_x^{*2}, which is a much more complex task, is taken up in section 3 in considerable detail.

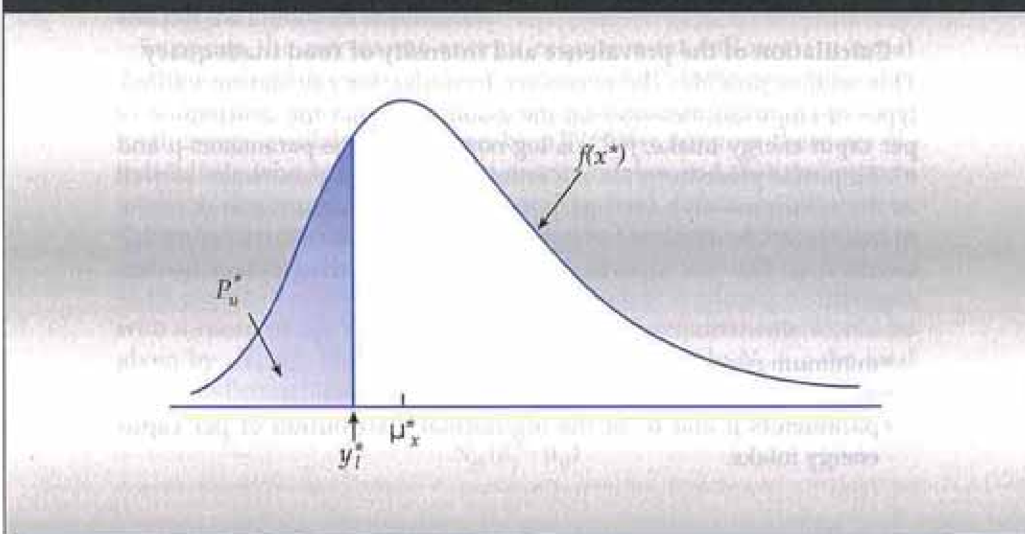
Thus, in the aggregated intake distribution approach, the minimum per caput energy requirement, y_T^*, is used in conjunction with an approximation of $f(x^*)$ to determine the proportion of the population with an inadequate intake, P_u^*, as shown in Figure 4.

It is evident that, as in the cases of the minimum and average energy requirements mentioned above, μ_x^* and σ_x^{*2} reflect the mean and the variance, respectively, of intakes expressed on the hypothetical average individual unit basis. This implies that, in the above aggregated distribution approach,

$$I^* = \sum_{j=1}^{M} W_j$$

FIGURE 4

PROPORTION OF POPULATION WITH AN INADEQUATE INTAKE, BASED ON THE AGGREGATED INTAKE DISTRIBUTION APPROACH



which represents the hypothetical average individual, is the unit of analysis (and hence the units classified in the inadequate category) and the distribution is free from the effects of differences in intakes between individuals owing to age and sex. Since I^* is equal to 1, it follows that:

$$N I^* = N$$
$$\text{and } P_u^* \simeq N_u/N$$

and hence:

$$NP_u^* \simeq N_u = P_{u1}n_1 + P_{u2}n_2 + ... + P_{uM}n_M$$

This means that the aggregated distribution approach is expected to provide approximations that are consistent with the estimates obtained by considering the individual age-sex-specific cutoff points and intake distributions separately. In addition, the extent to which the estimates based on the aggregated distribution approach can provide good approximations of the true proportion and number of individuals with an intake below their respective cutoff point depends on the accuracy of the approximated aggregated intake distribution, $f(x^*)$.

It is evident from the above exposition that, in the aggregated distribution framework, the population is assumed to be composed of N hypothetical average individuals; the average individual, I^*, being defined as the average of one individual from each of the M age-sex groups weighted by the respective population shares. In this way, the unit of the intake distribution is made consistent with the unit underlying the concepts of minimum and average per caput energy requirements. Hence, for convenience, the aggregated intake distribution is also referred to as the distribution of "per caput intake".

Calculation of the prevalence and intensity of food inadequacy

This section provides the necessary formulae for calculating various types of empirical measures on the assumption that the distribution of per caput energy intake, $f(x^*)$, is log-normal with the parameters μ and σ^2. Empirical procedures for the estimation of these parameters as well as the minimum and average per caput energy requirements at the country level are discussed in Specification of the distribution of intake, section 3, p. 132. The numerical values of the following parameters are required:

- minimum per caput energy requirements, y_l^*;
- average per caput energy requirement, μ_y^*;
- parameters μ and σ^2 of the log-normal distribution of per caput energy intake.

Having obtained the country-specific values for the above parameters, it is possible to provide analytical expressions for various measures of interest.

Prevalence of food inadequacy. The prevalence of inadequate access to food is measured using the probability that the average individual's intake will be less than y_l^*, which is given by:

$$P\text{ (inadequate)} = P_u^* = P\,[x^* < y_l^*] = \Phi\ \left(\frac{\ln y_l^* - \mu}{\sigma}\right)$$

where $\Phi(t)$ is the area under the standard normal curve to the left of the point t.

Assessing the intensity of food inadequacy. The intensity of food inadequacy indicates how far the access to food falls short of the desired level. It is measured from two perspectives, from that of the underfed, or undernourished, population and from that of the country as a whole.

Assessing the intensity of food inadequacy in relation to the undernourished. Two measures of the intensity of food inadequacy among the undernourished are discussed here: the absolute food deficit (or simply food deficit) and relative food inadequacy.

A simple measure of food deficit is derived by calculating the extra amount of energy needed to bring all the individuals whose intake is below the minimum requirement up to that level, a measure that is often computed in most empirical exercises. However, this measure underestimates the extra amount of energy needed to meet the requirements of all the people with an inadequate intake. This is because, as discussed earlier, the aggregate intake norm that will satisfy the requirements of all individuals in a group is given by the average and not the minimum requirement.

Suppose the per caput energy requirement follows a normal distribution with a mean of μ_y^* and variance of σ_y^{*2}. If the population size is N, then the total requirement of the population is given by $\mu_y^* N$. The total energy availability is given by $\mu_x^* N$. Now suppose there are N_u individuals who have inadequate energy intakes and that the average intake of this group is denoted by μ_u. The food deficit should then be defined as the extra amount of energy needed for the undernourished to meet their aggregated requirements. Since these individuals are from the same population, their requirements also follow a normal distribution with a mean of μ_y^*. Therefore, their aggregated requirements would be given by $N_u\,\mu_y^*$. The total amount consumed is only $N_u\,\mu_u$; the total energy deficit or "total food deficit" would therefore be:

$$N_u\,(\mu_y^* - \mu_u)$$

The deficit expressed as a percentage of total energy availability ($\mu_T^* N$) is called the "relative inadequacy" of the current food availability and should therefore be represented as:

$$\frac{N_u\,(\mu_y^* - \mu_u)}{N\mu_x^*} = \frac{P_u^*\,(\mu_y^* - \mu_u)}{\mu_x^*}$$

The calculation of the above formula also requires a numerical value for the average intake of the undernourished (μ_u). This can be computed by taking the average of the intakes corresponding to the part of the distribution of x^* below y_1^*, as follows:

$$\mu_u = \frac{\int_0^{y_1^*} x^* f(x^*)\,dx^*}{\int_0^{y_1^*} f(x^*)\,dx^*}$$

Assessing the intensity of food inadequacy in relation to the country as a whole. This measure indicates how much greater the per caput DES should be in order to reduce the prevalence of food inadequacy to a minimum or target level. The construction of this measure entails first estimating the required per caput DES level and then comparing it with the actual per caput DES. To estimate the required per caput DES level, two alternative strategies may be considered, reflecting two distinct assumptions about distribution: one assumes food supply growth with the existing inequality in distribution and the other takes into account the effect of a reduction in inequality to the fullest extent feasible. Since the more unequal the distribution is, the higher the required level of per caput DES would be, other things remaining the same, the two assumptions would lead to an upper and lower limit for the required level. Furthermore, by examining the implications that a full reduction in inequality would have for the prevalence of food inadequacy while keeping the per caput DES at the present level, it is also possible to see in which cases redistribution would suffice, in which cases growth would have to play the predominant role and in which cases a combination of the two would be needed.

i) Growth with no change in distribution. According to this strategy, the increase in food is assumed to trickle down to all households at the same rate, thus implying no change in the inequality measure as expressed by the coefficient of variation (CV). To derive the target per caput DES level, $\bar{x}_T$, the first step is to determine the mean of the intake distribution in the log scale (μ_T) that will result in the targeted level for the proportion with an inadequate intake (p_T), on the assumption that the standard deviation (SD) in the log scale (σ) remains at the present level; and the second is to translate the resulting mean into the mean in the original scale.

The first step is undertaken by equating the normal deviate of the intake level at the cutoff point in the log scale to the standard normal deviate corresponding to the targeted percentage level, which can be expressed as follows:

$$(ln\ y_1^* - \mu_\tau)/\sigma = - z_{p\tau}$$

so that:

$$\mu_\tau = \sigma\, z_{p\tau} + ln\ y_1^*$$

The required per caput DES can then be obtained by using the following formula for the mean of the log-normal distribution in the original scale:

$$\bar{x}_\tau = \exp\,(\mu_\tau + \sigma^2/2) \qquad (1)$$

Increasing the average per caput energy intake without any change in the distribution of intake has the effect of shifting the intake distribution to the right, which reduces the proportion of population with deficient energy intakes but, at the same time, increases the proportion of population with excessive energy intakes.

ii) Redistribution and growth. In the preceding case, the inequality in distribution as measured by the CV is assumed to remain unchanged. As will be explained later, the CV is considered to vary between a minimum of 0.20 and a maximum of 0.35. Hence, when the CV is close to 0.20, the assumption of no change in the inequality of distribution is relevant. However, higher values, particularly if they are close to the upper limit of 0.35, imply that there is scope for reducing the prevalence of food inadequacy through redistribution programmes, for example by reducing the inequity in income distribution. Reducing the inequality parameter implies a higher share of the food supply growth for people with a low intake and hence a lower per caput DES target.

In view of this, it may be useful to consider the alternative strategy of first assessing the prevalence of food inadequacy on the basis of the current per caput DES and the minimum value for the inequality parameter in the log scale, σ. The resulting prevalence of food inadequacy would reflect the potential effect of a full decrease in inequality. If the prevalence estimate is still below the target level, then a growth in per caput DES becomes necessary. The target level of per caput DES in the above context is obtained by simply substituting the minimum value for σ in Equation (1) (above). The approach of considering the full effect of redistribution when calculating the required per caput DES level is attractive, since it represents the minimum per caput food supply that will be needed if the prevalence of food inadequacy has to be reduced to the chosen target level.

3. STATISTICAL FRAMEWORK FOR PRACTICAL ASSESSMENT

The basic theoretical underpinnings of the methodology for the assessment of food adequacy formed the core of the previous sections. This section focuses on the empirical procedures necessary to derive estimates of: i) the minimum and average per caput energy requirements; ii) average per caput energy intakes; and iii) a measure of variability in per caput energy intake expressed by the CV.

The estimation of these three vital elements is explained below; however, methods of estimation are necessarily conditioned by the type of data available and a few comments on the nature of the primary data are therefore offered, together with a few caveats that are necessary for a proper interpretation of the numerical results derived.

Statistical database

As described earlier, the minimum and average per caput energy (calorie) requirements are derived by aggregating the lower-limit and average energy requirements estimated for individuals belonging to the different age-sex classes, using the age-sex composition of the population as a weight. Thus, the distribution of population by different age-sex groups is needed for each country. In addition, an estimate of the total number of births in any year is also necessary to derive the special energy needs of pregnancy and lactation. This information is essentially demographic in nature and the relevant data are available for most countries (UN, 1993). The age-sex-specific minimum and average energy requirements are derived on the basis of appropriate body weight and activity norms (see James and Schofield, 1990).

The average per caput energy (calorie) intake figures are based on national per caput dietary energy supply (DES) figures derived through the food balance sheet approach. The food balance sheets form an important component of the agricultural statistics system at FAO and are compiled using data from a variety of sources after close scrutiny for any inconsistencies. The data, which are available for most countries in the world, are the only major source of statistics for global food and nutrition studies.

However, the per caput DES figure from the food balance sheets, while reflecting the average food consumption level, does not necessarily provide an accurate measure of the actual energy consumption or intake level of a population, the principal reason being that it includes the food losses or wastage at the retail or kitchen/plate levels. A proper assessment of the actual intake level requires information from special surveys that measure the nutrition levels of households or individuals in a population, i.e. food consumption or dietary surveys. However, nationally representative surveys of this kind are costly and time-consuming to implement and have consequently been undertaken in very few countries. For this reason, FAO has to rely on the DES data while assessing the prevalence of food inadequacy in the developing world. Precise statistics on the extent of the bias resulting from the use of the per caput DES data in this context are not available. However, a study of household food wastage in the United Kingdom showed that wastage accounted for an average of 6.5 percent of the energy intake in summer and 5.4 percent in winter (Wenlock *et al.*, 1980). Since the percentages are likely to be lower in the developing countries, it may be assumed that the extent of the upward bias in the average intake level, as reflected by the per caput DES, is not likely to be large.

The per caput DES estimate needs to be supplemented by an estimate of the variance, σ_x^{*2}, to derive the distribution of per caput intake. A proper estimation of this variance also requires data on energy intakes of individuals classified by age-sex groups. Since such data are not available, the estimates have to be based on the only available sources of data pertaining to the distribution of food consumption within countries. These are the results of household expenditure surveys including data on food consumption and related variables. Household surveys provide data on household size and the total consumption of the households surveyed, thus leading to household-level data on per caput energy intake which can, in turn, be used as an approximation of the needed variance or CV of energy intake.[2] The household per caput variation, of course, does not refer to the equivalent units underlying the aggregated distribution framework discussed earlier. This unit, as indicated before, refers to the average individual with an age-sex composition defined as the weighted average of one person from each of the age-sex groups. The household per caput concept, on the other hand, while referring to an average of individuals in different age-sex groups, does not have a fixed age-sex composition, since this composition varies between households.

However, there is some empirical evidence to suggest that the variation in household per caput energy intake can provide a good approximation of σ_x^{*2}. Using detailed information on household intakes as well as the demographic characteristics of individual members of each household, an unpublished study on Tunisia found the SD of the logarithm of the household per caput intake to be about 1.0, while that of the household per consumer unit intake was about 0.8. As the consumer unit is also a standard unit with a fixed age-sex composition, this indicates that the household per caput variation provides a close approximation of the

[2] It may be noted that, in making this approximation, the intrahousehold variation referring to the differences between household members of different age-sex groups is ignored. This is precisely because, in the aggregate distribution framework, the unit of analysis is the average individual, i.e. a unit with a fixed age-sex composition. In other words, the distribution refers to units that are free from the effects of differences owing to age or sex.

variation between units that are free from the effects of differences in age-sex composition. A slightly different study of data from six regions covered by a Brazilian food consumption survey in 1974 showed that the contribution of differences in demographic factors in the variation of household per caput intake is relatively small.

It follows from the above that differences in body weight and activity levels and other socio-economic factors are likely to be the main contributors to the dispersion in household per caput energy intake. In view of this $\sigma_x^{*^2}$ is approximated by the variation in household per caput energy intake while the difference between these two estimates is expected to be small.

Minimum and average per caput energy requirements

As mentioned before, the minimum and average per caput energy requirements are obtained as the weighted average of the lower limit and average requirement, respectively, estimated for each age-sex group. It was also noted that the lower limit and the mean of the range of variation in energy requirements are in each case defined on the basis of the range of acceptable body weight and the range of acceptable activity norms. It is thus assumed that the energy requirements based on the combination of norms referring to a low body weight and light activity, on the one hand, and a heavy body weight and heavy activity, on the other, would reflect the range of variation in energy requirements for each age-sex group.

However, as explained in section 1, an exception to the above principle is made for children in age groups below ten years in the sense that the cutoff point or minimum energy requirement is set close to but below the average requirement. Thus, no allowance for variations in body weight is made and the norm is fixed at the median value of the range of weight for height given by the WHO reference curve. Similarly, the allowance for the effect of childhood infection for children below the age of two is taken as a fixed factor. However, the energy requirements per kilogram of body weight norms that are applied to the specified body weight include a 5 percent allowance to account for the fact that the energy intakes of the reference groups on which they were based do not reflect the optimum activity levels for children. This extra allowance is not included when defining the cutoff point. Therefore, the 5 percent extra allowance was excluded for the latter purpose but included for the purpose of the average requirement. Thus, the contribution of children below the age of ten to the minimum and average per caput requirement differed only with respect to the 5 percent extra allowance relating to activity.

As regards the adolescent and adult age-sex groups, the body weight for determining the lower limit of energy requirement is based on the lower limit of the range of acceptable weight for height, while activity is taken to be that corresponding to the light activity norms, i.e. 1.55 BMR for males and 1.56 BMR for females.

The body weight for the average requirement is determined on the basis of the median of the acceptable range of weight for height, and activity on the basis of the moderate activity norms, i.e. 1.78 BMR for males and 1.64 BMR for females.

However, the reference standard given by the New York Society of Actuaries for the range of acceptable weight for height was not considered to be applicable for populations in developing countries. Recent studies of the body mass index (BMI) have suggested that a BMI range of 18.5 to 25.0 is compatible with good health and physical functioning (Shetty and James in FAO, 1994b).[3] The range of acceptable weight for given heights implied by the BMI range has therefore been adopted in defining the weight norms for adults and adolescents. The median value of the range is 22.0. Hence, for a given height, the lower limit and the median of the implied range of weight for height are derived on the basis of a BMI of 18.5 and 22.0, respectively.

The extra allowance for pregnancy applied to females in the reproduction age groups is 100 kcal/day for the minimum requirement and 200 kcal/day for the average requirement. The average height figures needed for determining the body weight norms for all age-sex groups were obtained from the tables given by James and Schofield (1990). The body weight and activity specifications underlying the minimum and average per caput requirements are summarized in Table 1.

The procedures for calculating the respective per caput energy requirements on the basis of specified body weight and activity norms are described in detail by James and Schofield (1990).

[3] The BMI refers to weight (kg) divided by height^2 (m).

TABLE 1

WEIGHT AND ACTIVITY SPECIFICATIONS FOR CALCULATING PER CAPUT ENERGY REQUIREMENTS

	Per caput energy requirement	
	Minimum	Average
Body weight		
• Children (ages 0-9)	• Median value of weight for height range	• Same as minimum
• Adolescents and adults (ages 10+)	• BMI 18.5 and average height	• BMI 22.0 and given height
Activity		
• Children (ages 0-9)	• Usual activity of children in affluent societies plus infection allowance for children up to two years of age	• Same as minimum plus 5 percent allowance for desirable activity
• Adolescents and adults (ages 10+)	• Males: 1.55 BMR Females: 1.56 BMR	• Males: 1.78 BMR Females: 1.64 BMR

Specification of the distribution of intake

In order to derive the proportion of population with an inadequate intake it is necessary to specify the nature of the distribution of energy intake. While there is no direct information relating to the distribution of intake, on the basis of the average individual unit it is evident that such a distribution would be positively skewed. On the basis of the few household surveys providing data on the distribution of households by level of per caput dietary energy intake or consumption (from a wide range of countries such as Brazil, Egypt, Indonesia, the Republic of Korea, the Sudan, Thailand and Tunisia), three theoretical density functions were tested: the normal, the two-parameter log-normal and the beta distributions. The log-normal distribution was found to outperform the other two distributions in terms of the standard test for goodness of fit and, for this reason, it was chosen to represent the distribution of per caput dietary energy intakes.

The density function of the log-normal distribution is completely characterized by the two parameters μ and σ^2. If μ_x^* and σ_x^{*2} denote, respectively, the mean and variance of the energy intake expressed on the "average individual" or per caput basis, then the four measures are related by the following two equations:

$$\sigma = \sqrt{ln\,(CV^2 + 1)}$$

$$\mu = ln\,\mu_x^* - \frac{\sigma^2}{2}$$

where $CV = \sigma_x^* / \mu_x^*$ is the CV of the per caput energy intake in a country.

Thus, the derivation of the log-normal distribution of intake for each country requires the estimation of the mean and the CV of energy intakes expressed on the average individual or per caput basis. The mean, as indicated earlier, is approximated by the per caput DES from the food balance sheets. Since the per caput DES is normally presented in terms of three-year averages, it excludes the effects of short-term random and seasonal variations and it is essential, therefore, that the CV also excludes these effects.

Estimating the CV of energy intakes. It is important that the CV is measured accurately, as it represents the inequality in the distribution of energy intake. A low CV implies less inequality in the distribution and, unless the average intake is close to the cutoff point, a lower prevalence of inadequacy, and vice versa.

The procedures employed to derive estimates of the CV are designed to measure it as accurately as possible and to make sure that the estimates reflect only the variability in per caput energy intakes and not that of other factors influencing the survey data used for purposes of estimation.

Relevant and irrelevant sources of variation. The household consumption data on which the estimate of CV is based are subject to variation owing to a variety of factors. It is therefore desirable to minimize the variability caused by factors other than the variability in energy intakes. The first factor in this process of minimization is the time frame. Since the per caput DES excludes the effects of short-term random and seasonal variations it has been recommended that the SD to be associated with it when deriving the distribution of household per caput calorie consumption should be standardized so as to reflect the consumption levels during a year. This recommendation arose from the consideration that most household surveys have tended to adopt the approach of distributing the sample equally and uniformly throughout the survey period (usually a year) and using a short reference period for data collection (a month, a week and sometimes even one day). In such a situation, the sample variance is expected to exaggerate the true variance for the survey period. In fact, the shorter the reference period, the larger the expected exaggeration.

There are, however, a number of other factors that tend to exaggerate the true variation, so it may be more appropriate to identify all the factors that are likely to contribute to this exaggeration and to distinguish between those that are relevant to the distribution of household per caput energy consumption and those that are not.

Following are the various sources of variation, classified into three groups.

Group A. Demographic and physiological
1. Household size
2. Body weight and height composition of individuals in household
3. Activity level of individuals in household

Group B. Economic and social
1. Income or purchasing power of household
2. Household preference
3. Local food accessibility

Group C. Survey procedure and consumption concept
1. Reference period of data collection at household level
2. Kitchen/plate wastage (if not excluded)
3. Food fed to pets (if not excluded)
4. Food given to guests or servants (if not excluded)
5. Measurement errors
6. Food eaten away from home (if not included)
7. Changes in household stocks (if not taken into account)

Since household consumption is expressed on a per caput basis, the effect of factor A1 (household size) is eliminated and only the remaining factors in Groups A and B are considered to be relevant. Therefore, every effort is made to eliminate the variability introduced by factors in Group C. The influence of survey factors is minimized by standardizing the reference period of the survey at *one year*. The other irrelevant effects from Group C are minimized through the estimation of the CV or variance on the basis of the averages corresponding to groups of households rather than the individual household data. The various types of survey errors and the related variance may be cancelled out during the process of averaging for the groups. Such groups are formed on the basis of the per caput calorie consumption level; the adjustment procedures are described in the section Adjusting the CV to exclude irrelevant variations in household per caput consumption, p. 137.

Methodologies for dealing with different data situations. The number of countries with data on the distribution of household per caput calorie consumption has increased significantly since *The Fifth World Food Survey* owing to a special data acquisition programme carried out in 1990-91 in collaboration with national statistical organizations or nutrition institutes in selected countries; nevertheless, these data are still not available for the majority of countries. Consequently, the general strategy adopted is to make the maximum use of any available information that had a bearing on the variation of energy intake among households of each country. Since information availability varied from one country to another, the techniques utilized are also varied.

The countries were classified into the following five categories, arranged in descending order according to the amount of data available:

Category A

Countries for which, in addition to food balance sheets, household-level data were available on energy intake, food expenditure and total income or expenditure.

Category B

Countries for which data similar to those for Category A existed but where the energy intake data were given only for groups of households classified in terms of income or expenditure.

Category C

Countries for which no energy intake distribution data were available, even for groups of households but for which the rest of the information characterizing Category B was available.

Category D

Countries for which there were no data on the distribution of energy intake or food expenditure but for which data were available on income or total expenditure distribution.

Category E
Countries for which there were no data except food balance sheets.

For Category A countries, the CV could be calculated directly from household-level data on energy intakes while, for the other categories, recourse had to be made to indirect methods which became progressively more indirect as the data grew scarcer. For countries in Category E, there was virtually no satisfactory basis for estimating the distribution parameter; their CV was therefore set equal to the weighted average of the CVs for countries in their respective regions.

The basic approach for estimating the CV for countries in Categories B, C and D is essentially the same as that described in the Appendix of *The Fifth World Food Survey* (FAO, 1987). Therefore, only the key features are given here.

The estimation was based on two considerations: first, energy intake is positively correlated with income or with total expenditure, taken as a proxy for income; and second, in so far as the variation in energy intakes is influenced by factors other than income, it is necessary to increase the income-induced variation to account for the non-income factors.

For a given country, it is assumed that the household per caput calorie consumption can be linked to household per caput income (or total expenditure) by the following regression equation:

$$x_i = \alpha + \beta \, ln \, V_i + e_i \qquad (2)$$

where *xi* is the per caput calorie consumption for the *i*th household, $ln\ V_i$ is the natural logarithm of the per caput income for the same household and e_i is the error term reflecting the composite effect of non-income factors. Assuming that e is independent of V, it follows that:

$$\sigma_x^2 = \beta^2 \sigma_{ln\,V}^2 + \sigma_e^2$$
$$= \beta^2 \sigma_{ln\,V}^2 / \gamma^2$$

where

$$\gamma^2 = 1 - \frac{\sigma_e^2}{\sigma_x^2}$$

The CV can then be formulated as:

$$CV(x) = \frac{\sigma_x}{\bar{x}} = \frac{\eta_x \sigma_{ln\,V}}{\gamma} \qquad (3)$$

where $$\eta_x = \frac{\beta}{\bar{x}}$$

Here, η_x is the income elasticity of household per caput calorie consumption taken at the mean household per caput consumption level, $\bar{x}$.

Thus, it may be noted from Equation ❸ (p. 135) that, given the value of $\sigma_{ln\ V}$, as estimated from the available income distribution data, the CV can be estimated on the basis of assumptions or estimates for η_x and γ. Since γ is the coefficient of correlation between energy intake and income, a greater influence of non-income variables will imply a lower value of γ and hence a higher value of the adjustment factor $1/\gamma$.

The value of $\sigma_{ln\ V}$ can be estimated directly from survey data, since surveys for all countries in Categories A, B, C and D report household distribution of income or its proxy, total expenditure. The same, however, is not true for γ, since no bivariate household data on energy intake and income (or total expenditure) are available for Categories C and D and, for Category B, they are available only in grouped form which fails to reflect the true correlation between household energy intake and income. An equation to estimate γ was therefore derived from the relevant household-level data available in the surveys of Category A countries.

This relationship was estimated for Category A countries through a regression analysis (cross-sectional), yielding the following empirical equation:

$$\gamma^2 = 0.114 + 3.28\ \eta_x^2 \qquad ❹$$

with $R^2 = 0.84$.

Using Equation ❸ (p. 135) and the calculated values of η_x, γ and $\sigma_{ln\ V}$, the CV of energy intake was estimated for each of the Category A countries and the observed CV was also calculated from the survey data; the difference was found to be slight in each case. Equation ❹ (above) was therefore used to estimate γ for the countries in Categories B, C and D.

For countries in Category B, survey results were available for dietary energy intakes by income class, so η_x could be estimated directly from the appropriate Engel's function fitted to the grouped data. In general, the semi-log form performed as well as or better than the other functions and it was therefore chosen for calculating the elasticities at the average intake level.

No data on the distribution of energy intake by income groups were available for the Category C countries but the food expenditure distributions were known. The latter enabled estimation of the elasticity of food expenditure (η_f) with respect to income. On the basis of this and an estimate of the ratio, η_x/η_f, η_x was derived. The ratio η_x/η_f was estimated through a regression equation linking it with the ratio of food expenditure to total expenditure.

Since food expenditure distributions were not available for the Category D countries, an indirect estimate of η_f was obtained on the basis of an equation linking the elasticity for food expenditure with other socio-economic variables. The procedure for deriving η_x was then the same as described above for the Category C countries.

It should be pointed out that the regression equations derived for the above-mentioned purpose of estimation reflect a pragmatic attempt to make full and effective use of all the available information from sources for all the countries (however incomplete these sources may be) in determining the CV of energy intakes for different countries. Their formulation has in fact been dictated by data availability rather than economically meaningful criteria. In view of this, their mechanical application, especially outside a certain range, is likely to lead to unacceptably high or low values for the estimated dependent variables and even the CV. This problem was, however, attenuated by the imposition of the 0.20 to 0.35 limits for the CV (see Adjusting the CV based on a sample distribution of household per caput calorie consumption [Category A countries], p. 140).

Adjusting the CV to exclude irrelevant variations in household per caput consumption. As mentioned earlier, the household consumption data from nationwide sample household surveys usually refer to a single reference period (a month, a week or, more rarely, one day) during a year; therefore, the estimated interhousehold CV is confounded by the within-year random and seasonal variations in a household's consumption. Furthermore, the survey design and methodology are rarely sufficiently precise to provide an unbiased estimate of actual household consumption during the reference period. In some cases, certain contributions to consumption are excluded; in others, consumption that should be excluded is included. Generally, household income and expenditure surveys have a questionnaire format that refers to food purchased or acquired during the reference period, making no distinction according to consumer, so food given to guests, visitors or tenants and food fed to pets and residual household wastage are included. Furthermore, food transfers to or from household stocks may not be adequately taken into account. Specialized food consumption or dietary surveys generally require the measurement of food consumed to be carried out by weighing the quantity of each food item prior to meal preparation as well as a record of the individuals partaking of the meals. In these cases, food eaten away from home is often excluded and the treatment of plate wastage varies. These measurement "errors" contribute substantially to the total mean square error.

It is the actual interhousehold average per caput variance relevant to the distribution that determines the estimate of the proportion below the cutoff energy adequacy level. It follows, therefore, that crude estimates of the CV based on a household survey with a single reference period need to be adjusted to allow for household variations and the non-sampling errors, as described above. As a basis for undertaking the adjustment, analyses of variance have been calculated for a limited number of data sets which allow the interhousehold and within-year components of the variance to be estimated.

Magnitudes of the interhousehold and within-year variation in household per caput dietary energy consumption. In order to assess the interhousehold and within-year variations, repeat measurements need to be made during the course of a year on a sample of households. The sets used derive from five subnational sample surveys of households, carried out by the International Food Policy Research Institute (IFPRI) in Bangladesh, Kenya, Pakistan, the Philippines and Zambia as part of a study on household food security, the nutritional impact of commercialization and food subsidies.[4] These surveys included repeat measurements, i.e. survey rounds, of the same sample of households over one year in order to reflect annual seasonal variations (see Table 2).

The analysis of variance was carried out on each of the above data sets by the Subcommittee on Nutrition (SCN) of the UN Administrative Committee on Coordination (ACC), in collaboration with IFPRI. The analysis provides the partitioning of the total variance into its between-round, interhousehold and residual components. Thus, if:

x_{ij} represents the per caput calorie consumption for household j in round i,
$\bar{x}_{\cdot j}$ the mean over rounds of household j,
$\bar{x}_{i\cdot}$ the mean over households of round i,

[4] IFPRI staff members responsible for the various country studies are: Eileen Kennedy (Kenya); Marito Garcia (Pakistan); Howarth Bouis (the Philippines); and Shubh Kumar (Bangladesh and Zambia). All are research fellows from the IFPRI Food Consumption and Nutrition Policy Division.

TABLE 2

AREAS COVERED, SAMPLE SIZE, NUMBER OF ROUNDS AND REFERENCE PERIOD IN IFPRI HOUSEHOLD CONSUMPTION SURVEYS

Country	Coverage	Sample size *(No. of households)*	Number of survey rounds	Reference period	Year of survey
Bangladesh	8 villages in Comilla, Pabna, Khustia and Jessore	301	3	One day	1982/83
Kenya	Nyanza	276	4	One day	1984/85
Pakistan	Districts of Attock and Faisalabad (Punjab), Dir (North-West Frontier Province), Badin (Sind) and Mastung (Baluchistan)	925	6	One week	1986/87
Philippines	Bukidnon	406	4	One day	1984/85
Zambia	10 villages in Eastern Province	116	12	One week	1985/86

$\bar{x}$ the mean of the total data set,
k the number of rounds, and
l the number of households,

the analysis undertaken gives the format shown in Table 3.

The variances resulting from the round effect (σ_r^2), the household effect (σ_h^2) and the residual effect (σ_{rh}^2) need to be estimated on the basis of the related mean squares, as follows:

$$\sigma_r^2 = (M_r - M_{rh}) / l$$

$$\sigma_h^2 = (M_h - M_{rh}) / k$$

$$\sigma_{rh}^2 = M_{rh}$$

The total variance is given as:

$$\sigma^2 = \sigma_h^2 + \sigma_r^2 + \sigma_{rh}^2$$

The SDs and CVs of the total variance and its components for each of the five surveys are given in Table 4.

The interhousehold CV ($\sigma_h/\bar{x}$) ranges from 0.17 to 0.37. In earlier studies, an acceptable range for the CV corresponding to 0.20 to 0.35 has been suggested.[5] The results of these country studies tend to confirm the plausibility of this range.

The between-round effect CV, ($\sigma_r/\bar{x}$) ranges from 0.03 to 0.14. This represents the effect of seasonal variations for which an adjustment should be made if the estimated CV is based on single visit, single reference period surveys. The residual CV ($\sigma_{rh}/\bar{x}$) ranging from 0.25 to 0.38, incorporates the effect of within-year changes in household characteristics

[5] A likely range for the CV of household intakes was derived by considering the range of dietary energy intakes and the implicit SD in a hypothetical population composed of active and adequately fed individuals. Since, in such a population, individual intakes are expected to match individual requirements, the range and implicit SD of intakes can be estimated from the requirement distribution. Using this argument in a previous study (FAO, 1975), an estimate of the SD of intakes was given as 750 kcal on a consumer unit basis. This translates into an SD of 600 kcal on a per caput basis. However, this figure refers to the true intake or consumption level, whereas the per caput DES refers to food availability, i.e. the true intake and a wastage factor. This wastage factor is thought to increase the SD of the distribution up to a maximum of 10 percent, leading to an SD for the DES distribution of approximately 660 kcal. The per caput DES figure for different countries generally varies from 1 900 to 3 400 kcal. Using this range and the estimated SD, a CV range of 0.20 to 0.35 is derived.

(i.e. the true household × round effect) as well as the composite effect of the random variation and the measurement errors discussed earlier. An adjustment to the CV should be made for the latter but not the former.

Adjusting the CV based on a sample distribution of household per caput calorie consumption (Category A countries). The adjustment procedure for countries that have surveys providing data on a sample distribution of household per caput calorie consumption follows three steps:

- *Reducing the effect of the random variations and the measurement errors.* Since the effect of the random variation (being confounded by other interaction effects) is not quantifiable, the approach adopted is calculated to make a pragmatic reduction that should significantly reduce the effect of such random variations on the CV. This involves the derivation of the percentile distribution of household per caput dietary energy consumption, followed by the adoption of the median values of each decile group as the group value used for estimating the mean and the SD and, hence, the CV. Thus, random variations within a decile group (but not between groups) are removed.
- *Removing the seasonal variation.* The number and geographical spread of the country case-studies analysed are not sufficient to calculate precise country- or region-specific allowances for seasonal variations, so a single adjustment is made to the estimates derived for all countries. The country analyses indicate that a reduction of 0.05 in the CV is a reasonable global average adjustment.
- *Imposing an acceptable range.* The resulting CV value is then considered to confirm that it lies within the acceptable limits of 0.20 and 0.35. If it is still above 0.35, it is rejected and the CV is assumed to be 0.35. Similarly, if it is less than 0.20, the CV is assumed to be 0.20.

TABLE 3

FORMAT OF ANALYSIS OF VARIANCE OF IFPRI HOUSEHOLD CONSUMPTION SURVEYS

Sources of variation	Sums of squares	Df[1]	Mean squares
Between-round	$S_r = l \sum_{i=1}^{k} (\bar{x}_i. - \bar{x})^2$	$k - 1$	$M_r = S_r / (k-1)$
Interhousehold	$S_h = k \sum_{j=1}^{l} (\bar{x}.j - \bar{x})^2$	$l - 1$	$M_h = S_h / (l-1)$
Residual or error	$S_{rh} = \sum_{j=1}^{l} \sum_{i=1}^{k} (x_{ij} - \bar{x}_i. - \bar{x}.j + \bar{x})^2$	$(k - 1)(l - 1)$	$M_{rh} = S_{rh} / (k - 1)(l - 1)$

[1] Degree of freedom.

Adjusting the CV based on income distribution data (Category B, C and D countries). The household income or total expenditure data are also to a certain extent subject to the types of short-term random and seasonal variations discussed with respect to calorie consumption. Therefore, in considering the removal of these variations from the estimated CV, the consequences for all the three parameters ($\sigma_{ln(v)}$ η_x and γ) on the right-hand side of Equation ❸ (p. 135) need to be taken into account. However, a precise assessment of the adjustments needed in each of these cases would require an appropriate analysis based on repeat measurements corresponding not only to calorie consumption but also to income (or total expenditure) on a sample of households. In the absence of such data, an approximative approach has been adopted in the present assessment.

For simplicity, it is assumed that the reduction in the variation of x implies a reduction only in σ^2_{e}, i.e. the non-income component of the variation, so that the γ value resulting from the fitting of Equation ❷ (p. 135) to the household-level data sets in Group A countries should be raised.

The adjusted γ values for Group A countries (where the CV has already been independently adjusted) can be obtained by taking the ratio of the variance explained by income to the adjusted total variance. In terms of the corresponding CV values, this is equivalent to the following expression for γ:

$$\text{adjusted } \gamma = \eta_x \sigma_{lnv} / \text{adjusted CV}(x)$$

Thus, the use of the adjusted γ values in calculating the regression Equation ❹ (p. 136) ensures the derivation of CV values that are to a

TABLE 4

SDs AND CVs OF TOTAL VARIANCE IN IFPRI HOUSEHOLD CONSUMPTION SURVEYS

Survey	SD				Mean	CV			
	Interhousehold	Between-round	Residual	Total		Interhousehold	Between-round	Residual	Total
	(σ_h)	(σ_r)	(σ_{rh})	(σ)	($\bar{x}$)	($\sigma_h/\bar{x}$)	($\sigma_r/\bar{x}$)	($\sigma_{rh}/\bar{x}$)	($\sigma/\bar{x}$)
	(kcal per caput/day)								
Bangladesh	469	70	567	738	2 232	0.21	0.03	0.25	0.33
Kenya	315	70	591	673	1 892	0.17	0.04	0.31	0.35
Pakistan	611	316	873	1 107	2 280	0.27	0.14	0.38	0.49
Philippines	487	73	565	750	1 855	0.26	0.04	0.30	0.40
Zambia	808	177	697	1 081	2 172	0.37	0.08	0.32	0.50

certain extent consistent with the definition adopted. In any event, as in the case of Group A countries, if the adjusted CV still falls outside the acceptable range of 0.20 to 0.35, it is either brought up to 0.20 or scaled down to 0.35.

For Group E countries where no distribution data are available, the procedure has been to adopt the weighted average of the CVs for the other countries in the region. In so far as the weighted averages are based on already adjusted CVs, no further adjustments are needed.

4. ESTIMATING THE PREVALENCE OF FOOD INADEQUACY: DIFFERENCES BETWEEN THE SIXTH AND FIFTH WORLD FOOD SURVEYS

This section briefly outlines the main differences between the approaches taken by the present and the previous survey in estimating the prevalence of inadequate intakes. The changes introduced in the present assessment refer principally to the problem of parameter specification rather than the basic methodological framework as adopted in *The Fifth World Food Survey*.

The principal changes introduced in *The Sixth World Food Survey* are summarized in Table 5.

TABLE 5

COMPARISON OF PRINCIPAL ELEMENTS OF THE SIXTH AND FIFTH WORLD FOOD SURVEYS

Elements involved	Sixth World Food Survey	Fifth World Food Survey
A. Distribution of intake		
• Mean	Per caput DES from food balance sheets	Same
• CV	i) Defined to reflect the interhousehold variation in consumption during a year. Hence, CV is adjusted to remove the effect of short-term random and seasonal variations ii) Assumed to remain constan through the different time periods considered iii) Constrained not to be greater than 0.35 or less than 0.20	i) Reference period undefined and hence CV taken as estimated from available survey data ii) Same iii) No constraint
• Shape of distribution	Log-normal	Same
B. Cutoff point (minimum per caput energy requirement)		
• Reference body weight	i) For children, taken as the median of the range of acceptable weight for height ii) For adults and adolescents, taken as the weight corresponding to a BMI of 18.5 and a given height	For children and adults and adolescents, taken as corresponding to the lower limit of the range of acceptable weight for height
• Activity allowance	i) For children, requirements reflect normal activity of healthy young children in affluent societies ii) For adults and adolescents, light activity with subsequent total requirement corresponding to 1.55 BMR for males and 1.56 BMR for females	i) Same, but including 5 percent increment to allow for insufficient activity among such children ii) Absolute minimum activity with subsequent total requirement corresponding to 1.4 BMR (average for males and females)
• Intra-individual variation in energy requirement	Considered as immaterial after allowing for variation in body weight and activity and excluding short-term variations	Taken into account, thus leading to the application of two alternative cutoff points
• Allowance for infection among children	Included	Not included
• Changes in the age-sex distribution of the population over time	Taken into account	Not taken into account