Annex 2

Methodology for assessing food security and progress towards the international hunger targets

Suite of food security indicators

Food security is a complex phenomenon, manifested in numerous physical conditions with multiple causes. *The State of Food Insecurity in the World 2013* introduced a suite of food security indicators, which measures separately the four dimensions of food security to allow a more nuanced assessment of food insecurity.

Updated data for the suite of food security indicators can be viewed and downloaded from FAOSTAT (at http://faostat3.fao.org/download/D/FS/E) and the FAO website (at http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/).

FIGURE **A2.1**

Suite of food security indicators

FOOD SECURITY INDICATORS	DIMENSION
Average dietary energy supply adequacy Average value of food production	AVAILABILITY
Share of dietary energy supply derived from cereals, roots and tubers Average protein supply Average supply of protein of animal origin	AVAILABILITY
Percentage of paved roads over total roads Road density Rail lines density	ACCESS
Gross domestic product (in purchasing power parity)	ACCESS
Domestic food price index	ACCESS
Prevalence of undernourishment Share of food expenditure of the poor Depth of the food deficit Prevalence of food inadequacy	ACCESS
Cereal import dependency ratio Percent of arable land equipped for irrigation Value of food imports over total merchandise exports	STABILITY
Political stability and absence of violence/terrorism Domestic food price volatility Per capita food production variability Per capita food supply variability	STABILITY
Access to improved water sources Access to improved sanitation facilities	UTILIZATION
Percentage of children under 5 years of age affected by wasting Percentage of children under 5 years of age who are stunted Percentage of children under 5 years of age who are underweight Percentage of adults who are underweight Prevalence of anaemia among pregnant women Prevalence of anaemia among children under 5 years of age Prevalence of vitamin A deficiency in the population Prevalence of iodine deficiency in the population	UTILIZATION

Source: FAO.

Prevalence of undernourishment indicator

The FAO prevalence of undernourishment (PoU) indicator measures the probability that a randomly selected individual from the reference population is found to consume less than his/her calorie requirement for an active and healthy life. It is written as:

$$PoU \equiv \int_{x<MDER} f(x)dx$$

where *f(x)* is the probability density function of per capita calorie consumption. The probability distribution used to infer the habitual levels of dietary energy consumption in a population, *f(x)*, refers to a typical level of daily energy consumption during a year. The probability distribution *f(x)* and the minimum dietary energy requirement (MDER) are associated with a representative individual of the population, of average age, sex, stature and physical activity level.

Estimating the PoU requires the identification of a functional form for *f(x)*, chosen from a parametric family. The parameters that characterize *f(x)* are the mean level of per capita dietary energy consumption (DEC) in calories; the MDER; the coefficient of variation (CV) as a parameter accounting for inequality in food consumption; and a skewness (SK) parameter accounting for asymmetry in the distribution.

To implement this methodology it is necessary to: (i) choose a functional form for the distribution of food consumption *f(x)*; (ii) identify values for the three parameters, that is, for mean food consumption (DEC), its variability (CV) and its asymmetry (SK); and (iii) compute the MDER threshold.

The choice of a functional form for the distribution

Starting from the Sixth World Food Survey in 1996,[1] the distribution was assumed to be lognormal. This model is convenient for analytical purposes, but has limited flexibility, especially in capturing the skewness of the distribution.

As part of the revisions made for the 2012 edition of *The State of Food Insecurity in the World*, the methodology moved away from the exclusive use of the two-parameter lognormal distribution to adopt the more flexible three-parameter skew-normal and skew-lognormal families.[2] The flexibility gained from the additional parameter allows for independent characterization of the asymmetry of the distribution.

As a further refinement, the data themselves are used in this report to inform the decision regarding the appropriate distributional form.[3] In this way, the empirical skewness from the distribution of per capita calorie consumption derived from national household surveys (NHS)[4] is applied as a selection criterion. Using the skewness implied by the lognormal as an upper limit for the level of asymmetry, the skew-lognormal, which embeds the lognormal as a special case, is used as an intermediate step to the skew-normal distribution, which itself is a more general form of the normal distribution. The resulting model makes it possible to account for reductions in inequality of food consumption, such as those made by targeted food intervention programmes, ensuring a smooth transition towards a distribution in which food consumption is symmetric.

Estimating and projecting mean food consumption

To compute per capita DEC in a country, FAO has traditionally relied on food balance sheets, which are available for more than 180 countries. In most countries, this choice was due mainly to the lack of suitable surveys conducted regularly. Through data on production, trade and utilization of food commodities, the total amount of dietary energy available for human consumption in a country for a one-year period is derived using food composition data, allowing computation of an estimate of per capita dietary energy supply.

During the revision for *The State of Food Insecurity in the World 2012,* a parameter that captures food losses during distribution at the retail level was introduced in an attempt to obtain more accurate values of per capita consumption. Region-specific calorie losses were estimated from data provided in a recent FAO study[5] and ranged from 2 percent of the quantity distributed for dry grains, to 10 percent for perishable products, such as fresh fruits and vegetables.

The last period for which the PoU is estimated is the three-year average 2014–16. This choice arises from the need to maintain consistency with previous assessments of undernourishment – which were based on three-year averages since 1990–92 – and the monitoring of the Millennium Development Goals and the World Food Summit goal, which ends in 2015 (see next section). The last period has to be a three-year average centred on year 2015, that is, 2014–16. Therefore, per capita DEC needs to be computed and projected up to the year 2016.

The latest available data from food balance sheets refer to year 2013 for most countries,[6] while for other countries data are available only until 2011. Therefore, additional sources were needed to estimate the DEC for the subsequent years. The main source of missing data for 2012, 2013 and 2014 are the food consumption estimates from the short-term market outlook prepared by the Trade and Markets Division (EST) of FAO. The Division computes per capita availability of major commodities – cereals, meats, oilseeds and sugar – for most countries of the world. These estimates were used to pro-rate the food balance sheet data to arrive at forecasts for 2012, 2013 and 2014. These forecasts are updated every six months, and need to be supplemented by projections for the most recent years.

The Holt-Winters distributed lag model was used to project the DEC for 2015 and 2016; in some cases, this model was also applied to compute projections for 2014, when EST data were not available or unreliable. The Holt-Winters model uses a process known as exponential smoothing, which attributes higher weights to more recent data and progressively less weight to older observations. Weights decrease in each period by a constant amount, which lies on an exponential curve. Where the Holt-Winters distributed lag model did not produce plausible results, simpler forecasting methods were used, such as linear or exponential trend extrapolations. For some countries, particularly where EST estimates appeared to provide implausible results, the econometric forecasting had to be applied for the whole projection period.

Annex 2

Estimating coefficients of variation and skewness[7]

A new data treatment method

Variability (CV) and skewness (SK) parameters are derived from NHS wherever they are available and reliable. These surveys typically collect information on food as part of the expenditure module. Data from these surveys, when taken as observations of individual habitual consumption, are affected by high variability. It is therefore essential to apply data treatment methods before parameters are estimated. This is especially the case for the SK parameter, which is sensitive to the presence of extreme values.[8]

The method applied in this edition of *The State of Food Insecurity in the World* to assess the robustness of statistics for a sample is known as the "leave-out-one cross-validation" approach. With this approach, for a sample of size *n*, subsamples of size (*n* – 1) are created in which each observation is systematically left out of one subsample. For each subsample, the sensitivity of the statistic of interest – in this case, the SK parameter – to the excluded observation can be analysed, and observations that have a large impact are removed. The method allows a robust calculation of the SK parameter that is insensitive to any single observation found in the dataset.

Controlling for excess variability

As the original purpose of NHS is to measure the levels and changes in living conditions of the population, the data collected typically pertain to food acquisition over a given reference period. However, the aim of the food security analyses in this report is to capture habitual food consumption, which is expected to be less variable than food acquisition. Therefore, excess variability is controlled by assuming a stable relationship between income and consumption in calories, which nets out excess variability caused by some households boosting their food stocks while other households deplete theirs. In the past, this control for excess variability has been accomplished by grouping household food consumption levels according to income deciles.[9]

In this edition of *The State of Food Insecurity in the World,* an extension of the method described above is used, based on a linear regression linking the log of per capita income to per capita calorie consumption, along with indicator variables for the month in which the survey was conducted, to control for seasonality. The regression can be written as:

$$PPC_i = \beta_0 + \beta_1 * \log(inc_i) + \beta_2 Month_{1,i} + \beta_3 Month_{2,i} + \cdots + \beta_m Month_{m-1,i}$$

where PPC_i is the per capita calorie consumption for household *i*, β_0 is an intercept term, β_1 is a regression parameter defining the linear relationship between the log of income and food consumption, and $Month_{j,i}$ is an indicator variable with value 1 if the survey for household *i* took place in month *j*. The variability in food consumption due to income is then calculated from the fitted values of the regression adjusted for seasonality.

A new estimation of indirect CVs

The procedure described so far is used in countries where one or more reliable NHS are available. Where this is not the case, so-called indirect estimates for the variability in food consumption are used. Indirect CVs were estimated by using the relationships between the CVs obtained from available household survey data and some key macroeconomic variables. In the past, the PoU indicator methodology was frequently criticized for holding CVs – which account for inequality in food consumption – constant over time for most countries.[10] This practice does not take into account economic progress within a country and changes in the distribution of food consumption. To address this issue, in this report, indirect estimates have been updated from the year 2000 onwards by using a revised relationship among the CVs due to income and macroeconomic variables that also takes into account changes in food prices.

To fully investigate the effects of food price changes on food access, measures of national prices should be used. In collaboration with the World Bank, FAO has developed a relative price of food indicator using data from the International Comparison Program[11] and consumer food price indices available on FAOSTAT.[12] The indicator is designed to capture changes in domestic food prices that are comparable over time and among countries. The ratio of food and general consumption in purchasing power parity (PPP) terms is projected forwards and backwards in time using the ratio of the country's consumer food price index to the country's general consumer price index, relative to that of the United States of America.

Using the most comprehensive dataset of Gini coefficients available,[13] a regression has been used to relate the variability in food consumption due to income to the log of GDP, the Gini coefficient, and the log of the relative price of food indicator. The GDP and relative price of food indicators are included on the log-scale, implying that changes in these variables at low values will have a larger impact on the CV due to income. To ensure cross-country comparability at different points in time, per capita GDP in constant 2005 international dollars in PPP terms, calculated by the World Bank, has been used. Regional indicators have been included for Africa, the Americas, Asia, and Western Asia. An interaction term between the GDP and the relative food price indicator has been included to allow for differential effects of the price of food at different levels of GDP. As there are multiple observations – more than one survey – for some countries, a weighted regression was used in which each observation is weighted by one over the number of surveys for that country.

With the parameters from the regression described above, the variability in food consumption due to income has been updated for countries with available Gini coefficients and available data on the relative price of food and GDP. Note that the Gini coefficients in the World Bank database differ in terms of whether they are calculated with reference to the household or the individual, consumption or expenditure, and gross or net income – these differences can make comparability across different types of Gini coefficient difficult.[14] For this reason, care was taken to ensure that the same type of Gini calculation was used within a single country and, to maintain cross-country comparability, only relative changes in the predicted values from the regression were used to update the CV parameter. The resulting updates take into account economic progress in a country as well as changes in relative food prices, allowing for a more complete picture of inequality in food consumption.

A new computation of variability due to requirement

To obtain the total variability in food consumption used to calculate the PoU, the variability that is due to income ($CV|y$) is added to the variability due to all other factors that are not correlated with income ($CV|r$):

$$CV(x) = \sqrt{(CV|y)^2 + (CV|r)^2}$$

Much of the variability orthogonal to income is due to differences in energy requirement, which are in turn largely determined by population structure as well as by physical activity levels, lifestyles, access to safe drinking-water, and progress in health care and disease reduction. Previous analyses showed small variability in this subcomponent across countries and over time, compared with the income component, and the variability due to requirement has been maintained at a fixed value.

To take into account the world's rapidly changing population structure,[15] time-varying country estimates for the variability in food consumption due to requirement have been calculated. Using estimates for the average dietary energy requirement by sex and age class[16] and corresponding population ratios[17] as weights, the variance due to requirement is estimated for a given country in a given year. Further work is under way to capture the rest of the variability that is orthogonal to income. The revision discussed here allows estimates of the variability in food consumption to reflect more accurately demographic differences across countries and demographic evolution within a country.

Estimating the MDER threshold

To calculate the MDER threshold, FAO uses normative energy requirement standards from a joint FAO/WHO/United Nations University expert consultation in 2001. These standards are obtained by calculating the needs for basic metabolism – that is, the energy expended by the human body in a state of rest – and multiplying them by a factor that takes into account physical activity, referred to as the physical activity level (PAL) index.

As individual metabolic efficiency and physical activity levels vary within population groups of the same age and sex, energy requirements are expressed as ranges for such groups. To derive the MDER threshold, the minimum of each range for adults and adolescents is specified on the basis of the distribution of ideal body weights and the mid-point of the values of the physical activity level (PAL) index associated with a sedentary lifestyle (1.55). The lowest body weight for a given height that is compatible with good health is estimated from the fifth percentile of the distribution of body mass indices in healthy populations.

Once the minimum requirement for each sex-age group has been established, the population-level MDER threshold is obtained as a weighted average, considering the relative frequency of individuals in each group as weights. The threshold is determined with reference to light physical activity, normally associated with a sedentary lifestyle. However, this does not negate the fact that the population also includes individuals engaged in moderate and intense physical activity. It is just one way of avoiding the overestimation of food inadequacy when only food consumption levels are observed that cannot be individually matched to the varying requirements.

A frequent misconception when assessing food inadequacy based on observed food consumption data is to refer to the mid-point in the overall range of requirements as a threshold for identifying inadequate energy consumption in the population. This would lead to significantly biased estimates: even in groups composed of only well-nourished people, roughly half of these individuals will have intake levels below mean requirements, as the group will include people engaged in low physical activity. Using the mean requirement as a threshold would certainly produce an overestimate, as all adequately nourished individuals with less than average requirements would be misclassified as undernourished.[18]

MDER thresholds are updated every two years based on regular revisions of the population assessments of the United Nations Population Division and data on population heights from various sources, most notably the Monitoring and Evaluation to Assess and Use Results of Demographic and Health Surveys project coordinated by the United States Agency for International Development (USAID). This edition of *The State of Food Insecurity in the World* uses updated population estimates from the 2012 revision published by the United Nations Population Division in June 2013. When data on population heights are not available, reference is made either to data on heights from countries where similar ethnicities prevail, or to models that use partial information to estimate heights for various sex and age classes.

Limitations of the methodology and frequent critiques

The FAO methodology for estimating undernourishment has been subject to long-standing and wide debate. The methodology suffers from several limitations, which need to be acknowledged and taken into account when analysing the results presented in this report.

First, the indicator is based on a narrow definition of hunger, covering only chronically inadequate dietary energy intake lasting for over one year. Energy intake is a very specific aspect of food insecurity, which applies where conditions are more severe. Individuals experiencing difficulties in obtaining enough food are likely to switch towards cheaper sources of energy and to compromise the quality of their food intake in a way that can create substantial damage.[19] To address this limitation, the FAO suite of food security indicators has been presented since the 2013 edition of *The State of Food Insecurity in the World*. The suite comprises indicators that reflect a broader concept of food insecurity and hunger and allows consideration of their multifaceted nature.

Second, the PoU indicator cannot capture within-year fluctuations in the capacity to acquire enough energy from food, which may themselves be causes of significant stresses for the population. Within-year fluctuations can also affect the quality of the diet, as consumers will resort to cheaper foods during periods when access becomes more difficult.

Third, the FAO methodology for computing undernourishment cannot take into account any bias that may exist in intra-household distribution of foods,[20] such as that arising from cultural habits or gender-based habits and beliefs. As seen, the parameters that describe the distribution of food across the population are derived from household-level surveys, rather than from information that refers to individuals.

A final and significant limitation of the FAO methodology for computing the prevalence of undernourishment is that it does not provide information on the degree of severity of the food insecurity conditions experienced by a population. The parametric model described in this annex only allows for estimates of the undernourished share in a population, but is silent about the composition of undernourishment within that part of the population.

In the debate on measuring undernourishment, the FAO methodology has attracted two frequent criticisms:

- The indicator underestimates undernourishment, as it assumes a level of physical activity associated with a sedentary lifestyle, while poor people are often engaged in physically demanding activities.
- The methodology is based on macrodata, whereas microdata from surveys allow accurate measurement of food consumption.

On the first criticism, ideally, undernourishment should be assessed at the individual level by comparing individual energy requirements with individual energy intakes. This would enable the classification of each person in the population as undernourished or not. However, this approach is not feasible for two reasons: individual energy requirements are practically unobservable with standard data collection methods; and individual food consumption is currently measured with precision in only a few countries and for relatively limited samples. The individual-level consumption data that can be estimated from NHS are largely approximated owing to disparities in intra-household food allocation, the variability of individual energy requirements, and the day-to-day variability of food consumption that can arise for reasons independent of food insecurity. The solution adopted by FAO has been to estimate the PoU with reference to the population as a whole, summarized through a representative individual, and to combine available microdata on food consumption with macrodata. Within the population, there is a range of values for energy requirements that are compatible with healthy status, given that body weight, metabolic efficiency and physical activity levels vary. It follows that only values below the minimum of such a range can be associated with undernourishment, in a probabilistic sense. Hence, for the PoU to indicate that a randomly selected individual in a population is undernourished, the appropriate threshold is the lower end of the range of energy requirements.

As for the second criticism, the FAO methodology in fact combines available microdata on food consumption derived from surveys with macrodata from food balance sheets. Food balance sheets provide information on the amount of food that is available for consumption after taking into account all possible alternative uses of the food items; hence, they provide approximate measures of per capita consumption, which are available for a large number of countries and are comparable. The methodology adopted for computing these data is currently under revision, together with the estimates of waste parameters used to derive the DEC, so the level of accuracy is expected to increase in the next few years. Survey data, where available and reliable, are used in the FAO methodology to compute the variability (CV) and skewness (SK) parameters that characterize the distribution of food consumption *f(x)*. It is therefore essential that household surveys collecting food consumption data are improved to obtain more accurate measures of undernourishment. Such improvements will require both promoting greater standardization across NHS, and conducting more refined surveys that capture food intake at the individual level. At the moment, few surveys accurately capture habitual food consumption at the individual level and collect sufficient information on the anthropometric characteristics and activity levels of each surveyed individual; in other words, very few surveys would allow for an estimation of the relevant energy requirement threshold at the individual level.

To conclude, the quality of the PoU estimates depends heavily on the quality of the background data used in the estimation. Hence, to obtain better estimates of undernourishment it is important to improve food consumption data through the design and implementation of high-quality nationally representative surveys that are comparable over time and across countries.

Criteria for identifying countries that have reached the MDG 1c hunger target and the 1996 World Food Summit goal

Following the recommendation of the Committee on World Food Security (CFS),[21] countries that have reached the two targets have been identified on the basis of the number of undernourished and the PoU.

The 1996 World Food Summit goal was defined in the Rome Declaration on World Food Security,[22] in which the representatives of 182 governments pledged *"... to eradicate hunger in all countries, with an immediate view to reducing the number of undernourished people to half their present level no later than 2015."* Estimates of the number of undernourished were used by FAO as a basis to monitor progress towards this goal.

With the establishment of the Millennium Development Goals, progress indicators were identified for each goal, to track progress at national and global levels. The reference period was identified as the 25 years between 1990 and 2015. The first MDG, or MDG 1, includes three distinct targets:

- halving global poverty;
- achieving full and productive employment and decent work for all; and
- halving the proportion of people who suffer from hunger by 2015.

The progress indicator for the third target, known as Target 1c, is the PoU.

FAO began monitoring progress towards the WFS and the MDG 1c hunger targets at the end of 1990s, using the three-year period 1990–92 as a starting point. Both targets are to be reached by the end of 2015. To maintain consistency with the initial time period and the definition of the targets of the MDGs, progress has been assessed up to a three-year average period centred on 2015, that is, 2014–16.

At the same time, achievement of all the MDGs is meant to be assessed for the 25-year period, from 1990 to 2015, but for the PoU, observations were only available for the 24-year period from 1990–92 and 2014–16. To address this potential inconsistency, the 50 percent reduction in the number of undernourished and the PoU needed to reach the WFS and the MDG 1c hunger targets, respectively, has been adjusted by a factor of 24/25. In practice, this means that a cut-off point of 48 percent has been used.