The State of Food Insecurity in the World 2012
Technical note

FAO methodology to estimate the prevalence of undernourishment

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Introduction

During the last five years the increased volatility of food prices and the availability of new sources of data on food access have emphasized the need for a revision of the FAO methodology[1] to improve the estimation of undernourishment. In 2010, an explicit call for a review of the hunger measure was raised by the Committee on World Food Security (CFS) and an Expert Round table was conducted in September 2011 to discuss the merits and drawbacks of existing methodology.[2]

The Round Table confirmed that the FAO methodology is fundamentally valid in its statistical principles, and that no viable alternative has been made available thus far to globally assess the extent of chronic food deprivation. However, the experts gathered in Rome also found that the methodology could be improved in several ways, especially by making fuller use of the increased number of available household expenditure and living standard measurement surveys, that could provide more information on food access distribution in the population.[3]

The experts also highlighted how the state of food insecurity in any country cannot be comprehensively assessed by reference to the prevalence of undernourishment only. It was unanimously felt that a core set of food security indicators is needed to capture the other dimensions of food insecurity, in addition to food calorie deprivation. The economic consequences of maintaining adequate caloric intakes in the face of growing food prices, as well as the nutritional implications of diets sufficient in terms of calories, but deficient in fundamental micronutrients ("hidden hunger"), have been identified as two major aspects deserving proper attention that are not captured by the Prevalence of Undernourishment indicator.

In view of the above conclusions and in response to the explicit request by the CFS, the evidence presented in this year's edition of SOFI is strengthened in two major ways. First, the entire series of undernourishment figures are updated, reflecting improvement both in the data and the method used to estimate. Second, an initial core set of indicators has been identified to convey information on various facets of food insecurity.

Both efforts should be seen as preliminary. They are the starting points of a continued endeavour to improve the monitoring of food security. While both the methodology and the conceptual framework for food insecurity assessment have been significantly amended this year to reflect improved data and information, further revisions are expected in the near future, as more reliable data on food waste and more surveys to assess the distribution of food access will be available. Also, though several additional indicators that can provide useful information on food security have been identified, coverage, in terms of countries and years, for many of them is still far from complete.

This technical note is intended to assist the reader to better understand the new evidence presented this year and the directions for future improvement in food security monitoring. Part I briefly describes the Prevalence of Undernourishment indicator and the way it is estimated, to clarify underlying concepts and limitations, Part II includes a description of the various data innovations and methodological improvements included in this 2012 edition of SOFI, compared to the traditional methods adopted previously, including a description of the proposed initial set of additional indicators.

[1] The FAO methodology for estimating undernourishment as traditionally applied until the 2011 edition of SOFI is extensively described in Naiken (2003).
[2] See: http://www.fao.org/cfs/cfs-home/cfsroundtable1/en/
[3] See http://www.fao.org/docrep/meeting/023/mc204E.pdf

Part I. FAO methodology to estimate the prevalence of undernourishment

Since its establishment, FAO has been charged with responsibility for monitoring the world food situation to enable the international community to appropriately direct actions aimed at promoting universal achievement of the right to adequate food. FAO's food security monitoring work involves, inter alia, estimation of the "Prevalence of Undernourishment" (PoU) indicator, routinely published in the annual *State of Food Insecurity* (SOFI) and widely used throughout the world by governments and international organizations.

This section aims at providing a concise yet comprehensive description of the PoU indicator to put the information it provides in proper perspective. It does so by clarifying which aspects of food insecurity are captured by the indicator, the concepts informing the methodology, and how available data are used to infer the estimates.

To properly assess the properties of an indicator and of the methodology used to estimate it, in fact, a clear definition of what the indicator is meant to capture should be provided. However, even clarity and agreement on its definition does not eliminate potential problems with an indicator including the statistical methodology or model chosen to measure it and the quality and appropriateness of the data used to "populate" the model. The scope and limitations of the PoU indicator needs to be reiterated, especially as major new methodological improvements are presented this year.

The text below highlights several points which must be considered in monitoring food security. First, departures from food security can involve many different situations (inadequate dietary energy intake, inability to satisfy food preferences, uncertainty about future ability to access food, etc.); hardly any single indicator is deemed sufficient to respond to the need for adequate monitoring. Second, it underlines that "to measure" in this context means "to estimate", which implies that the question is addressed in probabilistic terms. Although monitoring is needed in real-time, it is largely based on scattered and, often, rather imprecise data. As a consequence, the resulting margin of errors in the estimates may be rather large, though very difficult to precisely quantify.

A. Operational definition of "undernourishment"

The terms "undernourishment" and "hunger" have usually been interpreted as referring to a continued inability to obtain enough food, i.e., a quantity of food sufficient to conduct a healthy and active life.

Two issues have to be addressed in reaching a viable operational definition of undernourishment. First, considering the complexity of human nutrition, and both quantitative and qualitative dimensions of food, the expression 'enough food' needs to be qualified. The FAO method has been based on the measurement of the dietary energy intake, with 'enough' defined with reference to a normative dietary energy requirement benchmark established by nutritionists. Accordingly, a human being is considered undernourished if the level of his or her habitual dietary energy intake is below the minimum level nutritionists deem appropriate. As such, "undernourishment" can be considered an extreme form of food insecurity, arising when food caloric availability is inadequate to cover even minimum needs for a sedentary lifestyle.

Second, there is the question of the appropriate time span to assess undernourishment. For how long should an individual be deprived of the minimum caloric intake before he or she is considered "undernourished"? If our interest is in highlighting deep, chronic undernourishment, the reference

period should be long enough for the consequences of low food intake to be detrimental to health. Although there is no doubt that temporary food shortage may be stressful, the FAO indicator is based on a year, with the average consumption of food over the period referred to as the habitual level.

What the FAO indicator does not capture

Hence, the FAO indicator is designed to capture a clearly -- and narrowly -- defined concept of undernourishment, namely a state of caloric deprivation lasting over a year. As such, it does not capture, for example, costs associated with food procurement that do not result in reduced food consumption which may nevertheless have strong impacts on the quality of life of people striving to maintain adequate caloric intake.

The FAO indicator is not meant to capture short-lived effects of temporary crises unless those crises have long lasting effects on the ability of people to access food, or to distinguish the roles and impacts of external causes (e.g., production or trade shocks) from possible inadequacies of coping strategies (e.g., savings, changes in overall consumption patterns, food item substitution, etc.).

For a more complete description of the state of food (in)security, the Prevalence of Undernourishment (PoU) indicator has to be supplemented with a broader set of indicators to monitor various dimensions of food security.

B. Inferential process

The PoU estimator is based on the assumption of a distribution of energy consumption and a single energy requirement threshold for the *representative individual* in a population.

Admittedly, the need for such a relatively sophisticated statistical inference procedure is not obvious. The natural way to infer the proportion of undernourished individuals in a population would be to compare the food intake and requirements of individuals in a sample, to count the number of those whose food intake is below requirement.[4] However, both conceptual and data related issues exist that have caused FAO not to rely on such a simple procedure.

The major conceptual obstacle to implementation of this simpler (non-parametric) procedure is that an individual's dietary energy requirement is practically unobservable. Individual dietary energy requirements depend not only on clearly identifiable individual characteristics, such as body mass and level of physical activity, but also on a rather elusive individual degree of efficiency in food metabolism which cannot be easily observed or assessed. Normative food requirement standards can therefore only be given as ranges valid for *groups* of individuals (usually defined by age, gender and physical activity) in recognition of these many unobservable individual factors.[5] Lacking information

[4] Such a simpler estimation procedure based on direct use of survey data has been proposed. See Smith and Subandoro (2005), and Smith *et al*. (2006). It is usually referred to as a "non-parametric" approach, in contrast with the need for estimating a parametric distribution that is at the heart of the FAO method.

[5] "Estimates of energy requirements are derived from measurements of individuals. Measurements of a collection of individuals of the same gender and similar age, body size and physical activity are grouped together to give the average energy requirement - or recommended level of dietary intake - for a class of people or a population group. These requirements are then used to predict the requirements and recommended levels of energy intake for other individuals with similar characteristics, but on whom measurements have not been made. Although individuals in a given class have been matched for characteristics that may affect requirements, such as gender, age, body size, body composition and lifestyle, there remain unknown factors that produce variations

on individuals' actual body masses and levels of physical activity, there is a high probability of mismatching individuals with their requirements,[6] and this would be true even if individual habitual food consumption could be precisely recorded.

Further, information on food consumption, as provided by the surveys typically available to the FAO, has been found to be very imprecise and, in many cases, unrealistically high or low, undermining confidence that they can be used directly to classify individual households. Food consumption data from surveys usually refer to food *acquisition*, rather than *consumption*, with significant differences between the two. Referring to acquisition -- instead of consumption -- in a head count approach is likely, *ceteris paribus*, to overestimate the prevalence of undernourishment. In addition, evidence exists that many household consumption surveys fail to properly capture food consumed away from home, so that even the average household food consumption estimate may be biased.

In summary, to obtain reliable estimates from a non parametric approach, survey data should:
- cover all sources of food consumption, including those for which no expenses are incurred and the amounts consumed away from home;
- discerning actual food consumption from food acquisition over the surveyed period, recognizing that food may be acquired for other uses;
- allow to control for seasonal variations in food consumption;
- assess household members' dietary requirements, requiring data on height and physical activity level, in addition to gender and age.

As these characteristics are not usually present in most surveys, full reliance on a non-parametric approach can be misleading. When surveys do not satisfy these minimal requirements, the data they provide are still best used, together with other macro-level information, with a model-based approach, where the parametric model guarantees against the excessive, uncontrollable variability of household food consumption data.

Modelling assumptions and parameter estimates

In practice, implementing the inferential procedure requires some modelling assumptions that will have consequences for the characteristics of the estimates.

a) Individual dietary energy consumption

The FAO method is defined in terms of quantities available for consumption at the household level, inclusive of possible household-level food waste. Especially among food insecure households, for whom food is arguably particularly precious, such waste is presumably very limited. Second, even if household waste may be significant, it would be problematic to classify households who waste food to which they have gained access as food insecure, as would happen by applying the FAO method to the distribution of food intake. This effectively makes the FAO PoU estimate a conservative indicator of food insecurity.

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among individuals. Consequently, there is a distribution of requirements within the class or population group." (FAO/WHO/UNU, 2002, p. 5, emphasis added).

[6] To reduce that risk, and consequent errors in classifying households, data on the anthropometric and possibly on the occupational status of all household members should be collected, if a survey were to be used with a non-parametric approach.

b) How are calories distributed in the population

Related to the definition of dietary energy consumption is the assumption of how food is distributed among household members. Traditionally, the distribution of the dietary energy consumption in the population has been assumed to be log-normal, a statistical model that reflects some desirable properties for a distribution of food consumption (such as being only positive valued and positively skewed). [7]

The log-normal model is very convenient from an analytical point of view, as it is fully characterized by only two parameters: the mean and the coefficient of variation. Traditionally, the mean has been estimated using data on aggregate food supply (from the Food Balance Sheets compiled by FAO) divided by the country's population size, while the CV has been estimated from household food consumption data collected in various types of surveys (most often household expenditure and living standard measurement surveys).

Both sources of data have problems, as discussed below.

c) Caloric threshold

The threshold used to estimate the proportion of the undernourished based on the distribution of caloric consumption is estimated as the *minimum* of the range of energy requirement values from averaging the range of requirements of the various age and sex groups that compose the entire population.

The question of how to set the caloric threshold level to obtain the best estimate has been very controversial in discussions of the FAO method to assess undernourishment, linked to the unresolved question of whether humans adapt their food requirements to varying intake levels. [8]

In calculating the minimum in the range of energy requirements, reference is made to a Physical Activity Level (PAL) corresponding to a sedentary lifestyle. As many poor and hungry people are more likely to have livelihoods involving arduous manual labour, this is one other reason why the PoU estimator should be deemed a very conservative indicator of hunger; it also suggests that alternative indicators could be developed by using a higher minimum energy requirement threshold, calculated by considering a PAL corresponding to an active lifestyle.

C. Data problems

The FAO method embeds assumptions suggested by pragmatic considerations with careful attention to avoid bias. Nevertheless, all this is not sufficient to ensure great reliability of the estimates. The quality and reliability of the data used to estimate the parameters of the distribution and the cut-off point are crucial.

Thus far, the FAO has based estimates on three major categories of data, none of which is exempt from problems. The three groups are:

[7] The model was chosen more than fifteen years ago in preparing the estimates for the 1996 World Food Survey, corroborated with data from several high quality food intake surveys (in countries as diverse as Brazil, Egypt, Indonesia, the Republic of Korea, the Sudan, Thailand and Tunisia), which were better fit by the lognormal than by possible alternative distributions (Normal and Beta).

[8] For an extended discussion, see Cafiero (forthcoming).

1. Demographic data on population size and composition, as provided by official sources (UN Population Division, Demographic and Health Surveys (DHS), etc.)
2. Official data on production and trade as well as estimates of food and non-food uses of major commodities, used to assess aggregate food availability at country level, as reported by the FAO's Food Balance Sheets (FBS) (http://faostat.fao.org/site/368/default.aspx) compiled for a large number of countries in the world.
3. Data from nationally representative household income and expenditure surveys containing information on food expenditure.

As for population data, FAO uses official figures published by the UN Population Division, although these figures often diverge from the official population numbers reported by countries, thus giving rise to controversy. Population data affect the estimates in two ways. First, by affecting the measure of per capita food supply, and second, by determining the total number of undernourished associated with an estimated prevalence. Problems may arise when official population estimates are significantly revised backwards (as happened, for example with the 2010 population revisions for China and Bangladesh), changing the estimated per capita food supply.

FAO's Food Balance Sheets (FBS) are used as a source of information on total food availability in a country in a given year. Storable commodities, such as grains, contribute much towards total food availability in many countries. However, inventory levels are notoriously difficult to assess. Due to such problems, annual inventory changes, as recorded in the FBS, are deemed to be rather imprecise. For this reason, official estimates of the prevalence of undernourishment have been published as three year averages, to reduce errors in measuring stock variation by averaging.

One other issue related to use of FBS data as basis for estimating the average of the food consumption distribution is that FBS estimate supply at the beginning of retail, and therefore include food waste that may occur during retail distribution, thus introducing an upward bias in estimating average food consumption. Data on average food consumption could be also obtained from household surveys, when available. The problem there is that sizeable discrepancies have been known to exist between per capita food availability, as estimated by the FBS and by household income and expenditure surveys for the same country in the same year, which may be due to retail level losses, but also because food consumed away from home may not be captured by the surveys.

Data from household surveys, on the other hand, are the only source that can be used to directly estimate the other needed parameter of the food consumption distribution such as the Coefficient of Variation (CV). However, the type and quality of the data collected with typical expenditure and living standard measurement surveys have implications for estimating variability. To assess the caloric content of the food consumed, for example, one needs to identify the actual food items consumed. Most surveys only record acquisition of broadly defined categories of food, thus making conversion into calories prone to error. In addition, food acquisition over a reference period is often recorded, with no indication of when that food is actually going to be consumed, or by whom (as part of acquired food may go to non-household members).

The simple average of total calories acquired by the household is thus affected by errors that increase the variability of the measure of average habitual food consumption for the sample. To control for excess variability when estimating the CV, the FAO had devised an indirect estimation method, based on tabulation of food consumption data by household income decile, intended to control for excessive variability. The procedure consists of calculating the variation in average caloric consumption between

income classes, eliminating all variation within each class, to estimate the coefficient of variation "due to income". By doing so, however, all variation in food consumption not correlated with income is unaccounted for, including variation due to sex, age and body size, which are considered additional components of the total CV.

Even though the method is devised in terms of the representative individual, not the household, extensive data on food consumption in the population is only available at the household level. Food available at the household level is simply divided by the number of individuals in the household, meaning that unequal distribution of food within the household is ignored. Lacking reliable data on individual food consumption collected for nationally representative samples for virtually all developing countries, there is no alternative at the moment.

Projecting estimates when there are no data

Although published every year, the PoU indicator should only be calculated with reference to the years for which the latest data on food supply and consumption are available. Given the time required for data reporting, regular updates of Food Balance Sheets are conducted only up to two or three years earlier than the publication date. Even more problematically, lack of data has forced FAO to keep the values of CVs constant at those estimated in 1999, with occasional revisions such as for India when data from more recent household consumption surveys were made available to FAO.

To address this problem of lag in data availability, up to the 2010 edition of SOFI, preliminary estimates of the prevalence of undernourishment have been projected for the most recent years, based on forecasting models that used scenario based projections of food supply and demand, similar to those used by the USDA in their long term projections of food insecurity, instead of actual data. Reliability of such preliminary estimates has been questioned, as they depend on the robustness of the underlying assumptions.

D. Conclusions

To provide the international community with a comparable, periodic, worldwide assessment of the likely number of people suffering food deprivation, is a challenging task. If nationally representative surveys collecting reliable data on habitual food consumption were conducted every year and could be processed in a timely and consistent manner throughout the world, then a simple head-count method, based on the classification of individuals, could be used. Until then, a model based estimation procedure, such as FAO's, is still needed.

Information on food availability and access, as reflected by the FAO PoU estimates, while still necessary to monitor extreme caloric deprivation in the world, is clearly insufficient to provide needed guidance for policy actions, as there are other relevant dimensions of food and nutrition insecurity that cannot be thus captured.

In particular, there may be important welfare consequences of food price spikes that do not get well reflected in annual and triennial food caloric availability estimates, as households may sacrifice other consumption or needed investments, to maintain minimal caloric consumption.

To capture the whole spectrum of biological, economic and psychological stress associated with food insecurity, more research and different kinds of data are needed to develop a broader set of indicators.

Part II. Updating and overhauling the FAO methodology for the assessment of food insecurity– a summary of changes and their impacts

Several data improvements and methodological innovation have been included in this year report. This second part provides an assessment of the marginal impact of each innovation on the estimated numbers and prevalence rates, which should help make sense of the considerable differences between this year's and last year's assessments of the prevalence of undernourishment, defined in terms of access to dietary energy, in the world.

A. Substantial data innovations embedded in the undernourishment estimates

The new estimates are the result of considerable efforts in updating and improving the underlying database used. Updates have been obtained for data on food supplies, population, and the distribution of intra-national food access as recorded by household expenditure and living standard measurement surveys. While the changes should be considered as part of a comprehensive overhaul, to provide a sense of the impact of each of the revisions on the total number of undernourished in the developing world, table A1 reports the estimates published in SOFI 2011, along with the estimates that would have been produced by applying each of the revisions in sequence, with some indication of their effects at the margin, for the periods 1990-92, 1995-97, 2000-02, 2005-07 and in 2009, the latest year for which an assessment was conducted in 2011.

Population size

Updated information on population's size and structure is obtained from the latest revision of world population estimates (UN 2010) which include substantial revisions of population estimates for some countries with a large number of undernourished, such as China and Bangladesh. China's population estimate for the 1990s has been revised upwards by as much as 25 million people, with a resulting increase of both the prevalence and the absolute number of undernourished in the initial period, while Bangladesh's population has been revised downwards by about 11 percent (or 17 million people). The impact on undernourishment is thus different over the entire period. If the new population data were to be applied to the other data used for the estimates presented in SOFI 2011, we would have had an increase of 2.8% in the number of undernourished for the base period of 1990-92, and a reduction of 1.4% in 2009.

Human stature and energy requirements

A second revision relating to the population data has involved the average physical stature of people by sex and age. New data has been obtained from data collected through the Demographic and Health Surveys Program of USAID and from household surveys that report anthropometric statistics. On the basis of the revised heights, the reference Minimum Dietary Energy Requirement (MDER) for each country has been re-estimated. In some cases, this has led to significant changes in MDERs, and therefore, in the incidence of undernourishment, especially for countries for which data on heights were hitherto absent, and therefore assumed to be equal to those of other countries with similar ethnicities. As the revision has generally been towards a reduction of average heights, compared to what was previously assumed, implying a reduction of dietary energy requirements, the overall impact

attributable to this revision would only be a reduction in the estimated number of the undernourished over the entire period, ranging from -2.4% in 1990-92 to -3.1% in 2009.

Food supply

The next change considered relates to the total availability of calories. The FAO Statistics Division has recently published new estimates of dietary energy supply for all countries in 2009, with revisions of the entire series. Differences with respect to past estimates can be found over the entire series, but have been substantial only for the latest periods. Use of the updated values of dietary energy supply would determine, everything else unchanged, an increase in the estimated number of undernourished in the initial periods (+ 1.5% in 1990-92, and +1.4% in 1995-97) and a reduction in the latest ones (-0.2% in 2000-02, -3.8% in 2005-07, and -8% in 2009).

Food losses

The presence of food losses occurring at the retail distribution level has been identified in the past as a known source of bias in the FAO estimates of undernourishment using the Food Balance Sheets' DES to estimate the mean distribution of food consumption (see Sibrian, Komoroska and Mernies 2005). Lack of reliable estimation of the extent of such losses, however, has prevented considering them in past estimates. A first step has been taken with this edition of SOFI towards correcting the estimate of the mean dietary energy consumption at household level, by introducing a parameter for food losses occurring during distribution at the retail level. Country specific values of the average per capita loss of calories have been estimated based on data provided in a recent FAO study on food losses at various stages of the commodity chain, revealing that significant losses of food may occur during retail distribution, that is from the moment food is made available for human consumption at the wholesale level, to the moment it reaches the households. Estimates presented by Gustavsson *et al.* (2011) vary by region and by category of food, ranging from 2 percent for dry grains to 10 percent for fresh fruit and vegetables. Applied to the various components of the FBS, these coefficients of losses imply an overall reduction in terms of calories available for human consumption at the household level, thus increasing the estimated number of undernourished.

Of all the revisions being considered, this is the one that causes the most dramatic change in the estimated prevalence of undernourishment in the world, with impacts ranging from +13.2% in 1990-92, to +16.4% in 2007/09. These estimates of food losses during distribution and storage are still tentative, based on rough regional aggregates published in the referenced FAO study, expected to be refined in the future, as more precise country-specific estimates become available.

B. Improvements in the estimation methods

Recently, the Statistics Division of FAO has conducted a thorough revision of the undernourishment methodology, elements of which have been presented and discussed in various fora, including a Round Table organized by the Committee on World Food Security in September 2011, and at the International Symposium on Food and Nutrition Security in January 2012. While the review confirmed the overall validity of the fundamental approach, it also revealed scope for improvement. The changes introduced with this edition of SOFI concern (a) the functional form used for the distribution of dietary energy consumption in the population and (b) the way in which the needed parameters, namely the average, the coefficient of variation and the skewness of the distribution of

habitual food consumption in the population, are estimated. These changes strengthen both the theoretical soundness and the empirical validity of the underlying inferential method.

The distributional model

Since it was first adopted in 1996, the Log Normal specification for the distribution has not been changed, and updates have been limited to the revision of the mean dietary energy consumption (based on data published in the Food Balance Sheets) and to occasional revisions of the coefficient of variation, when data from more recent household consumption surveys were made available to FAO. In all other cases, the lack of adequate food consumption data from nationally representative surveys did not warrant changes in the coefficient of variation, which was therefore kept constant. Raising the mean, while keeping constant CV under the lognormal distribution, however, has the consequence of also increasing the probability associated with high levels of consumption, something that may raise doubts on the adequacy of the distribution used in the latest years in many countries, where the distribution of food access may have become less skewed than what is implied by the log normal model. For this reason, a more flexible model (the Skew-Normal introduced by Azzalini in 1980) has been deemed more appropriate to represent the distribution of habitual food consumption in the population; compared to the previous one, this model can now capture changes in the asymmetry of the distribution of food consumption; such changes could derive, for example, from targeted food supply schemes, which only affect a specific part of a population and which could not have been captured by the approach applied in the past.

Parameter estimates: the mean dietary energy consumption

A known source of bias in the FAO estimates of undernourishment is the lack of reliable information on the extent and depth of food losses. Criticisms were thus raised of the practice of using dietary energy supply, as published in the FBS, as the mean of the distribution of calorie consumption in the population. This edition of SOFI has taken an important step in responding to this criticism to correct the bias. The estimated mean of the distribution of caloric consumption is now lower than the Dietary Energy Supply by a coefficient that reflects food losses incurred during distribution and at the retail level, and estimated on data provided in a recent FAO study for all regions in the world (see discussion on food losses above).

Parameter estimates: coefficient of variation and skewness of food consumption distribution from household survey data

In the past, the coefficient of variation of the distribution of dietary energy consumption in the population was the only parameter used to represent the inequality in the distribution of food consumption. The parameter was estimated differently for different countries, depending on the availability of data. A revision of these estimates has been long overdue. Thanks to the collaboration of FAO with the National Statistical Offices responsible for household survey data collection and dissemination, FAO has not only updated the estimates of coefficients of variation, but for the first time allowed for estimation of the skewness of the distribution of food consumption in the population. A total of 47 surveys have been processed, ranging from 1995 through 2010. As most of these surveys are income and expenditures surveys, they have not been designed to specifically capture the level of yearly habitual food consumption of the individuals living in the surveyed households, but rather the total household’s acquisition of food during a short reference period (from one week to one month). In

most cases, it has thus been necessary to re-process the available household level information to control for excess variability due to seasonal variation in food expenditures and to the difference between the reported food *acquisition* levels over a short period, and the needed average yearly food *consumption* levels. Other sources of spurious variability in the food consumption data obtained from these surveys come from the facts that (i) food acquired may be given out to guests or persons other than household members, and (ii) households may have been either using food from household stores during the reference period, or conversely having purchased food to build up stocks. All these problems called for the application of careful procedures to control for data quality and to process the data available to obtain the estimates of the coefficient of variation and skewness of individual habitual consumption.
In the end new parameters have been obtained for 37 countries that together cover almost 70% percent of the number of undernourished in the developing world. For the remaining countries, lacking new usable evidence, the coefficient of variation (and the implied skewness) have been kept unchanged to the values used in the past.

Projections when data is missing

New data on the distribution of food supply across households and on human stature and energy requirement, obtained from surveys, is not available for all countries and all years covered. This created the need to devise proper methods to project the new information to years in which no survey data is available, both for the food distribution and food requirements.

a) Projection of food distribution parameters.

Until last edition of SOFI, coefficients of variation of habitual food consumption were kept fixed at the values estimated in 1996 in preparation for the World Food Survey (FAO 1996). Under the assumption of a log normal distribution, these values of CV imply also a fixed value for the coefficient of skewness.[9]
As noted, in this edition of SOFI we have calculated the CV and the coefficient of skewness of per person habitual food consumption in each country and each year when a suitable survey was available. For the years in between two surveys, the missing information on CV and skewness has been estimated with a simple linear interpolation of the two parameters. The same linear interpolation has been applied to the five years preceding the first available survey, by using the old parameters as starting point.
For the years following the latest available survey, we kept the CV and skewness constant to those estimated from latest available survey. These figures will be changed when new surveys will be available.

b) Projections of stature and dietary energy requirements

The dietary requirement threshold in a country (the MDER) is calculated as an average across sex and age groups in the population. To estimate energy requirements for each sex and age category, we use

[9] As the lognormal distribution is fully characterized by only two parameters (μ and σ) , the skewness coefficient is a simple monotonic transform of the standard deviation, $SK = \left(e^{\sigma^2} + 2\right)\sqrt{e^{\sigma^2} - 1}$, and can also be conveniently expressed as a function of the coefficient of variation, according to the following formula: $SK = (CV^2 + 3) \times CV$. This makes it clear that, when assuming a lognormal model, the skewness cannot be changed independently of the coefficient of variation.

the median height of people in that group as revealed by surveys reporting anthropometric measures.[10] When more than one survey is available for a country we project the heights from the oldest survey retrospectively, and project forward those from the most recent one. For years in between surveys, we linearly interpolate the median heights in each sex and age group.

Application of the changes in the methodology, including the change in the distributional model and the new parameters for variation and skewness, on top of all the other revisions already discussed, would have generated changes in the estimated number of undernourished in the developing world ranging from an increase of 2.3% in 1990-92 and 2.7% in 1995-97, to reductions of 2.4%, 3.9% and 3.8% respectively for 2000-02, 2005-07 and 2009.

The graphs in Figure A1 visualize the effects of the various changes described. The result of the comprehensive revision of data and methodology presented with this issue of SOFI is an overall impact on the estimated number of undernourished of +17.9% in 1990-92 and of -1.5% in 2009 if compared to the assessment that would have been made based on last year data and with no methodological changes.

C. Introducing a core set of additional food security indicators

Following the recommendation that emerged from the CFS Round Table on hunger measurement, an initial set of suitable indicators aiming at capturing various aspects of food insecurity has been defined whose values will be available in the companion website of this issue of SOFI.

The choice of indicators has been informed mostly by availability of data with sufficient coverage to enable meaningful comparisons across regions and over the years. While most of these indicators are already being produced and published by the FAO and other international organizations, there are also indicators introduced for the first time, to fill some of the recognize gaps in food security information systems, most notably in the ability to capture the economic dimension of food insecurity.

To facilitate interpretation of the proposed indicators, they are classified along two dimensions. First, a distinction is made between indicators that describe *determinants of food insecurity* and those that describe *outcomes*. The first set includes indicators that describe structural conditions potentially conducive to food insecurity in absence of adequate policy interventions, including emergency assistance, while the second set aims at capturing the end results of food insecurity, irrespective of any policy intervention or coping strategy has been put in place.

Within the first groups, indicators are then classified based on the *dimension* of food insecurity on which they provide information, namely: *availability, physical access, economic access (or affordability), utilization* and *vulnerability*. Similarly, outcome indicators are classified in different groups, depending on whether they refer to the outcomes in terms of *inadequate food access, anthropometric deficits due to inadequate food utilization, or observed instability*.

Those ideally forming a core set are highlighted in bold, while an asterisk identifies the new ones, being introduced for the first time, and which are briefly described in the following.

[10] As energy requirements are provided as a function of body masses, the median height of an individual in a group is used to estimate the minimum body mass compatible with healthy status for the typical individual in that group. We do so by considering the weight that would yield a body mass index equal to the fifth percentile of the distribution of normal body mass indexes, according to the WHO.

- **Relative Dietary Supply Index**. It is the ratio of the Dietary Energy Supply in the country, expressed on a per capita basis, net of food losses, to the country Average Dietary Energy Requirement (ADER), a measure of the average caloric needs of the population that depends on the age/sex structure and on the heights of people. It provides indications on the scarcity of food relative to the needs in each country.

- **Food Price Level Index**. It is an index of the food price level in each country that is comparable across countries and over time. It is based on the Purchasing Power Parities (PPP) calculated within the context of the International Comparison Program by researchers at the World Bank. The PPP relative to the food aggregate, available for 2005, is projected over time by taking into account the food and general inflation rates in each countries, as measured through the evolution of Consumer Price Indexes (CPI) – both food CPI and general CPI – published by the International Labor Organization and FAOSTAT.

- **Share of Food Expenditure by the poor**. This indicator measures the average share of total expenditure spent on food by the households that belong to the lowest income (the first 20%) group. It is compiled based on data from household expenditure surveys, and aims at capturing the economic consequences of rising food prices and poverty. A rising share of food expenditure reflects the hardship that poor families face when trying to maintain food consumption when either food price rise or income falls, by sacrificing on other household expenses. Coverage in terms of countries and years for this indicator is conditioned by the availability of survey data.

- **Prevalence of food inadequacy**. It is conceptually analogous to the prevalence of undernourishment, but calculated setting the caloric threshold to a higher level corresponding to the energy need for moderate physical activity (PAL = 1.75). It measures the percentage of the population that is at risk of not covering the food requirements associated with normal physical activity, and therefore including also those who, even though they cannot be considered undernourished, are likely being conditioned in their economic activity by insufficient food. While the PoU is an estimator of chronic food deprivation ("hunger"), this new estimator is a less conservative measure of food inadequacy in the population.

- **Domestic Food price volatility**. It is an index of the year-to-year variability in the annual Food Price Level Index, aimed at capturing the consequences of all factors that determine local imbalances in the food market. Together with the other two indicators of variability in the domestic food production and of food supply, provide an indication of the past ability of a country to maintain a stable food economy.

The full list of proposed indicators is included in table A3.

This suite of indicators is intended to become the basis for the compilation of a possible food security composite set of indexes. Ideally, indicators conveying information on each dimension could be aggregate into single dimensional index (i.e., an index of the state of food availability, one of food access, one of food utilization and one of vulnerability) which would form a "food security scorecard" for each of the monitored countries. This will require (i) a normalization/scaling process of each of the indicators and (ii) the definition of a proper a weighting/synthesis process to aggregate the normalized indicators into a single dimensional score.

The food security scorecard then will be the natural basis for the compilation of a possible comprehensive food security index, where the single dimensional indexes are aggregated according to the relevance that is attributed to each of the dimension.

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Table A2. Impact of various changes in the data and methodology

	1990-92	1995-97	2000-02	2005-07	2008-10	2010-12
As in SOFI 2011	**833**	**774**	**821**	**839**	**856**	
+ Population change	+24	+12	+12	-5	-11	
	(+2.8%)	(+1.5%)	(+1.4%)	(-0.6%)	(-1.4%)	
+ Heights change	-21	-25	-28	-24	-26	
	(-2.4%)	(-3.2%)	(-3.3%)	(-2.8%)	(-3.1%)	
+ Calories change	+12	+10	-2	-31	-60	
	(+1.5%)	(+1.4%)	(-0.2%)	(-3.8%)	(-8.0%)	
+ Food Losses	+112	+114	+124	+125	+125	877
	(+13.2%)	(+14.8%)	(+15.5%)	(+16.1%)	(+16.4%)	
+ Methodology changes	+20	+23	-22	-34	-32	-25
	(+2.3%)	(+2.7%)	(-2.4%)	(-3.9%)	(-3.8%)	(-2.9%)
New assessment	**980**	**909**	**905**	**870**	**852**	**852**
Overall changes	**+17.9%**	**+17.5%**	**+10.2%**	**+3.6%**	**-1.5%**	

(Note: marginal changes due to each revision in parenthesis)

Table A3. Food security indicators available on SOFI's companion website

Type of indicator	Source	Coverage	Core	New
1. Determinants of (or inputs to) food insecurity				
Availability				
Average Dietary Supply Adequacy	FAO	1990 – 2012	*	*
Food Production Index	FAO	1990 – 2012	*	
Share of energy supply derived from cereals, roots and tubers	FAO	1990 – 2012		
Average protein supply	FAO	1990 – 2012		
Average supply of protein of animal origin	FAO	1990 – 2012		
Physical Access (conditions for physical access to food)				
Percent of paved roads over total roads	Int. Road Fed.n	1990 - 2009		
Rail-lines density	WB	1990-2010		
Road density	WB, Transp. Div.	1990-2009		
Economic access (affordability)				
Food Price Level Index	FAO/WB	1990-2010	*	*
Utilization				
Access to improved water sources	WHO/UNICEF	1990-2010		
Access to improved sanitation facilities	WHO/UNICEF	1990-2010		
2. Outcomes				
Inadequate access to food				
Prevalence of undernourishment	FAO	1990-2011	*	
Share of food expenditure of the poor	FAO	partial	*	*
Depth of the food deficit	FAO	1990-2011		*
Prevalence of food inadequacy	FAO	1990-2011		*
Utilization (food related anthropometric failures)				
Percentage of children under 5 years of age who are stunted	WHO/UNICEF	1966-2010	*	
Percentage of children under 5 years of age who are wasted	WHO/UNICEF	1966-2010	*	
Percentage of children under 5 years of age who are underweight	WHO/UNICEF	1966-2010		
Percent of adults who are underweight	WHO	1974-2010		
3. Vulnerability/Stability				
Domestic food price volatility	FAO/ILO	1990-2010	*	*
Per Capita food production variability	FAO	1980-2010		*
Per Capita food supply variability	FAO	1980-2010		*
Political stability and absence of violence/terrorism	WB WGI	1996 – 2010		
Value of food imports over total merchandise exports	FAO	1990-2009		
Percent of arable land equipped for irrigation	FAO	1990-2009		
Cereal import dependency ratio	FAO	1990-2009		

Figure A1. – Impact of various changes in the data and methodology