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Revision of the methodology for the estimation of the Prevalence of Undernourishment

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1. Introduction

FAO has produced estimates of the Prevalence of Undernourishment (PoU) and of the Number of Undernourished (NoU) since 1974, when a first global and regional assessment was published with the fifth World Food Survey.

The 1996 World Food Summit, hosted by FAO, set the target set at of reducing by one half by the year 2015, the number of undernourished in the world, and established the NoU as the indictor used to monitor progress towards this target. Since 1999, country level estimates of the PoU and NoU, in addition to regional and global aggregates, were published in the State of Food Insecurity report (SOFI). A few years later, the Millennium Development Goals (MDG) established the eradication of extreme hunger and poverty as the first of their eight goals, and officially adopted the POU as an indicator to monitor progress towards one of this goal's targets, that of reducing by one half by the year 2015, the proportion of people suffering from hunger.

Due to the high visibility received by these FAO indicators since publication of the Sixth World Food Survey in 1996, they have been the subject of intense debate (Osmani, 1996), some criticism (Svedberg, 1999; Smith, 1998), and suggestions of possible alternatives to inform the monitoring of global food insecurity and hunger (FAO, 2003; Smith et al. 2006). In spite of the

sometimes heated debate, no alternative proposal has yet been established as a viable alternative for the global monitoring of hunger. The FAO indicators continue to be published regularly every year, and furthermore, are used as one of the components of the Global Hunger Index (proposed by the International Food Policy Research Institute in 2006) and in virtually every food security monitoring system in the world.

The debate surrounding these indicators gained intensity after FAO's publication of the 2009 and 2010 editions of SOFI, in which projections estimated a dramatic increase in the estimated number of hungry, associated with what was believed to be a widespread food price crisis following events of 2007-2009. The jump in the number of undernourished, posited to have occurred in 2009, led commentators to voice concerns about the reliability of the FAO method to estimate the number of hungry. These concerns culminated in the request to FAO by the Committee of World Food Security, in its 27th session, to organize a Technical Round Table to discuss the FAO measures of undernourishment.

The outcomes of the Round Table,[1] which took place on 12 and 13 September 2011 at FAO headquarters in Rome, gave impetus to the set of revisions and innovations implemented since, which this paper presents. The objective of this paper is to provide a reasoned account of the various elements that have informed the revision, and to promote further discussion to gain consensus on yet further possible improvements.

The paper is organized as follows. Section 2 summarizes the PoU methodology and addresses some common misconceptions about it. Section 3 presents the revisions implemented since 2011. Section 4 introduces possible further developments and advances recommendations for discussion.

2. The FAO methodology for computing the PoU

The methodology for estimating the PoU is based on the comparison of a probability distribution of habitual daily Dietary Energy Consumption, $f(x)$, and a threshold level, called the Minimum Dietary Energy Requirement (MDER). Both are based on the notion of an average individual in the reference population (FAO 1996, Appendix 3, pp.114-143, and Naiken 2003). Formally, the PoU is estimated as follows:

$$PoU \equiv \int_{x<MDER} f(x)dx \qquad (1)$$

[1] A synthesis of the results and recommendation of the Round Table on Measuring Hunger is available at: http://www.fao.org/fileadmin/templates/cfs/Docs1011/CFS37/presentations/CFS37_Round_Table_On_Hunger_Estimates_Gennari.pdf

The PoU is the probability that after randomly selecting an individual from the population, s/he is found to be consuming an amount of calories insufficient to cover the energy requirement for an active and healthy life. This probability is taken as an estimate of the likely proportion of people that are undernourished in the population. An estimate of the Number of Undernourished (NoU) is then produced by multiplying the estimated PoU by the population size. The PoU and NoU have been adopted as indicators to monitor progress towards the targets set with the MDG (in particular, the hunger target of MDG One) and at the World Food Summit, respectively.

The probability distribution used to draw inference on the *habitual* levels of caloric consumption in a population, $f(x)$, refers to a typical level of daily caloric consumption *during* a *year*. As such, $f(x)$ does not capture occasional caloric consumption levels that may prevail over shorter periods of time. If and only if the *average* consumption over such a period is below requirement, the indicator would signal a condition of undernourishment. Given that both the probability distribution *f(x)* and the threshold level in (1) are associated with a typical individual in a population -- of average age, sex and stature -- *they do not represent the empirical distribution of per capita food in the population.*

Estimating equation (1) requires an analytic expression for *f(x)*, and the identification of the MDER. The functional form for the probability distribution *f(x)* is chosen from a parametric family. Its characterization is obtained by estimating parameters for the *mean,* the *variance,* the *coefficient of variation* and the *coefficient of skewness.* FAO Statistics Division continually endeavors to improve estimates of these parameters based on available data from various sources.

To estimate per capita calorie consumption in a country, FAO has traditionally relied on its own Food Balance Sheets (FBS), which are available for more than 180 countries. This choice was mainly due to a lack of suitable surveys conducted on a regular basis in most countries. Calories available in a country for a one year period are derived from FBS and food composition data, leading to the computation of per capita Dietary Energy Supply (DES). A parameter that captures food losses during distribution at the retail level is employed to deduct losses from the DES. Region-specific values of average calorie losses have been estimated based on data provided in a recent FAO study of food losses (Gustavsson *et al.* 2011), ranging from 2 percent of the quantity distributed for dry grains, to up to 10 percent for perishable products, such as fresh fruit and vegetables.

Data from representative national household surveys are the only reliable source to directly estimate the other parameters of food consumption distribution. When survey data on food

consumption is unavailable, an estimate can only be obtained indirectly.[2] Available survey data comes from different types of household surveys that collect information on food consumption, including income, expenditure and living standard measurement surveys.

The features and the quality of the information collected in available survey data have implications for the estimates of habitual caloric consumption. In this connection, two main issues are noteworthy

First, while undernourishment is considered an individual condition, data on food consumption are usually only available at the household level. Hence individual consumption has to be approximated by dividing food available to the household by the number of household members.

Second, food consumption data are usually collected in surveys in terms of quantities acquired over a reference period. These quantities need to be converted into calories consumed. The conversion of food quantities into calories and the distinction between acquisition and consumption often requires large approximations. The daily average amount of calories acquired by a household over a period is only a rough measure of the daily calories consumed by each member, and over- and under-estimations tend not to compensate for one another.[3] The resulting sample variance of food consumption would therefore be an incorrect estimator of the variance of habitual food consumption in the population. The same problem applies to the estimate of the coefficient of variation (CV) of food consumption *of the representative individual* included in the PoU estimate.

To control for excess variation in the data, per capita caloric consumption figures are tabulated by household income classes and the variation in average caloric consumption *between* income classes is calculated.[4] The resulting CV – labelled as "due to income"($CV|y$) - excludes variability in habitual food consumption that is uncorrelated to household income. The "total" CV of habitual food consumption for the representative individual is then obtained as:

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

[2] When no data is available on the distribution of actual food consumption, parameters related to the variability of food access can be estimated based on the distribution of food expenditures, on the inequality of income distribution or, in the worst case, on child mortality rates (see Naiken, 2003, pp. 14-15).

[3] It is not uncommon to observe values lower than 800 or in excess of 5000 kcal, clearly unreliable measures of habitual daily caloric consumption.

[4] This was obtained by calculating the coefficient of variation assigning to each individual a level of calorie consumption equal to the median value of per capita calorie consumption recorded among the households grouped in the same income class.

where $CV|r$ reflects variation due to factors that induce variability in food consumption and are not correlated to income.[5]

The CV and skewness are computed through a regression that decomposes total variation of food consumption into two components: one that reflects the variability of habitual food consumption; and the other which is unrelated to food insecurity. Research is continuing at the FAO Statistics Division on how to optimally decompose the total variation in available surveys.

To calculate the Minimum Dietary Energy Requirement (MDER) - that is, the requirements of the representative individual in the population - FAO employs reference body weights, as provided by nutritionists. These, in turn, are obtained by calculating the needs for basic metabolism (i.e. the energy expended by the human body in a state of rest), and multiplying the latter by a factor greater than one to take into account the physical activity level (PAL) associated with a normal and active life, namely, the PAL index.

However, individual metabolic efficiency and levels of physical activity are variable, even within groups of the same age and sex. Hence, caloric requirements can only be expressed as ranges. As mentioned before, FAO refers to the minimum of such ranges, given that only consumption below the minimum can, with certainty, be associated with undernourishment.

The MDER for adults and adolescents of a given sex and age is specified on the basis of the lowest body weight and the lowest PAL index which can be considered compatible with good health and a normal active life. The lowest acceptable body weight for a given height is estimated on the basis of the fifth percentile of the distribution of body mass indices (BMI) in healthy populations, and the PAL index corresponding to light activity (1.55) is taken to reflect the lowest acceptable activity level.[6] It is important to note that the minimum refers to light physical activity, which is normally associated with a sedentary lifestyle, and does not neglect the fact that this group can also include persons engaged in moderate and intense physical activity. It is an analytical approach that avoids overestimating food inadequacy when only food consumption levels are observed, and when there is variability in food consumption also among those who are adequately nourished.

Once the minimum requirement in each sex-age group is established, the threshold to be considered for the average individual is obtained as a weighted average, considering the relative frequency of individuals in each group as weights.

The value of the MDER is updated every two years, based on regular revisions of the populations assessments of the UN Population Division as well as data on population heights

[5] See Naiken, 2003, pp.13-14
[6] For a detailed description of the procedure, see Naiken, 2003

from various sources, most notably the Monitoring and Evaluation to Assess and Use Results of the Demographic and Health Surveys (MEASURE DHS) project coordinated by USAID (http://www.measuredhs.com). When data on population heights are not available, reference is made either to data on heights from countries where similar ethnicities prevails, or to models that use partial information to estimate heights for various sex and age classes.

3. The 2011-2012 revision

As already mentioned, the methodology just described has been used since estimates were prepared for the Sixth World Food Survey in 1996. The fundamental assumptions about how to conduct the inference and on the functional form of the distribution did not change until 2011. Regular updates are provided and annually embed new estimates of the mean of the distribution based on revised FBS data, and every two years, incorporate population data revisions, with implications on the revision of MDER values.

Due to the inability to obtain and process adequate data from household surveys, including both food consumption surveys and demographic surveys, the CVs of the food consumption distribution and the data on population heights had not been revised for the vast majority of countries until 2011. The context was that of a general perception that an international economic crisis was occurring, and that it was coming immediately after the "so called" food price crisis of the summer 2007, when the international food price index compiled by FAO had peaked to levels unseen for many years.

It should be noted that FAO PoU estimates could not have been expected to capture the impacts of both phenomena, simply because of the time required to collect, validate and process data that would reveal the extent to which both crises had affected the size and distribution of food consumption across the population. With SOFI 2009, an attempt was made, nevertheless, to predict the likely impact of the crises using a scenario based model inspired by an approach developed by the U.S. Department of Agriculture (USDA). The most pessimistic scenario was that of a generalized economic crisis affecting all countries in the world, coupled with a general food scarcity that many thought was associated with high food prices. The model predicted that such a scenario could bring the number of undernourished in the world to exceed one billion, garnering an unprecedented level of attention by the international community, including at FAO.

The apparent dramatic increase in the number of undernourished from one year to the next, however, also raised some questions on the reliability of the FAO estimates. However, many critics failed to appreciate the difference between the meaning of the traditional estimates, and the

early predictions based on a scenario that still needed to be validated. Concerns were raised at various levels, most notably within the 36th session of the Committee on World Food Security in 2010, when FAO was explicitly requested to host an Expert Round Table to review the methods for hunger measurement.

Preliminary results of the methodological review were presented as soon as February 2011 at a workshop on *Measuring Food Insecurity and Assessing the Sustainability of Global Food Systems*, hosted by the U.S. National Academies of Science, and extended discussions conducted during the round table hosted by FAO in Rome in September 2011. At the time, revised estimates of the prevalence of undernourishment in 2008, based on the traditional methodology, started to reveal that some of the assumptions of the pessimistic scenario leading to the one billion figure had, in reality, luckily failed to materialize.

The review of the methods were completed by February 2012 and presented at the International Scientific Symposium on Food & Nutrition Security Information, "*From valid measurement to effective decision-making*," hosted by FAO in February 2012, and introduced revised methods used to inform SOFI 2012 later that year. The main conclusions of the review were the following:

- The methodology based on the distribution of access to calories within the population is sound, as it is based on solid statistic inferential principles.
- Considering the quality and type of data currently available, there is yet no superior alternative for annual monitoring at global level.
- Nevertheless, the estimated prevalence of undernourishment is insufficient to provide a comprehensive picture of the state of food insecurity of a country or a region, as it is based on a narrow definition of individuals' access to insufficient caloric supply. As such,
    - it does not capture the consequences of food insecurity in terms of welfare losses (sacrifice of other essential consumption to protect minimum caloric intake), *and*
    - it does not consider the nutritional value of calorie-sufficient diets that may lack other nutrients (amino-acids, vitamins, etc.).
- For these reasons, it is recommended that a core set of food insecurity relevant indicators should be produced to allow for regular monitoring of the various dimensions that constitute Food Security (availability, access, utilization and stability).

4a. Details of the revision: Data

The first revision involved a new assessment of country level food supplies. The FBS series for all countries monitored by FAO were updated for the period up to 2009. Preliminary estimates for 2010, 2011 and 2012 were produced, based on the trends observed in the commodity

balances maintained by the FAO for major food commodities, covering about 80% of the average caloric supply.

The revisions also took into account new world population estimates, published in the 2010 by the UN Population Division. Revision of population data had two impacts on estimated figures: first, by affecting the per capita value of the dietary energy supply, because a given amount of total availability of calories for food supplies gets divided by a different number of people; and the second, by affecting the estimate of the number of undernourished people, as the estimated prevalence of undernourishment gets applied to the new population size. Contrary to previous revision, the 2010 revision included major changes in population data for some large countries, such as China, Bangladesh, Myanmar, Indonesia, Pakistan and Afghanistan, with resulting large revisions in the whole series of estimated prevalence and number of undernourished.

Perhaps the major data innovation included in the revisions concerns the fact that data from 45 national household surveys were used to derive new parameters of the distribution of households' access to calories, including not only the CVs, but also, for the first time, an estimate of the skewness (asymmetry), which was possible to implement thanks to the relaxation of the assumption of lognormal distribution (see below). Revised parameters were produced for 31 countries, representing almost 70% of the undernourished population in the world in 2009.

In addition, data on populations' heights were revised using new data from Demographic and Health Surveys and other household surveys data with anthropometric modules. The new data on heights, in turn, were used to revise estimates of the MDER for the involved countries, in some cases quite significantly. The new MDER data now range from a minimum of 1651 Kcal/day, as estimated for Timor Leste, to a maximum of 1991 Kcal/day, estimated for the Netherlands (which is currently the country with the tallest population across most sex and age classes).

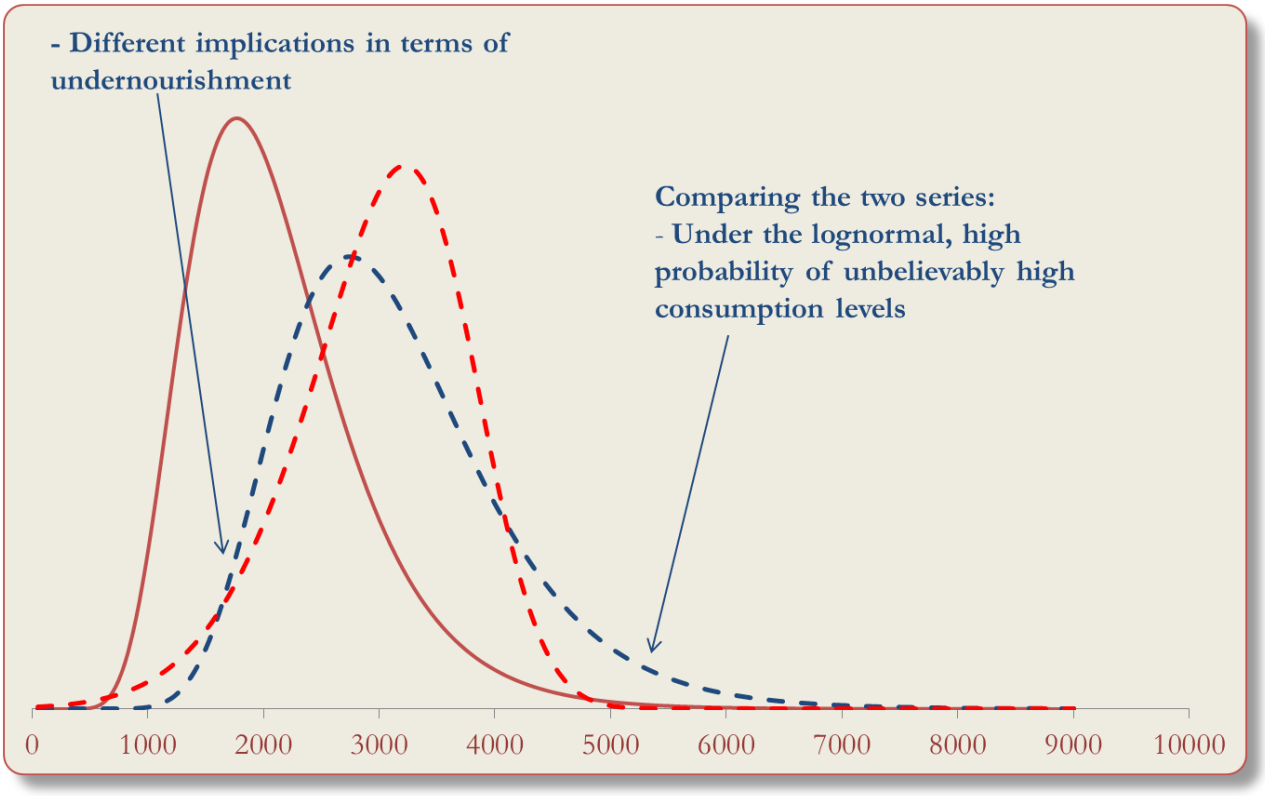
4b. Improvement in methods

Parallel with the update of the data, three actions have been taken to improve the methods used to conduct the inference.

First, the mean of the distribution of habitual caloric consumption in the country is no longer estimated simply as the Dietary Energy Supply obtained from FBS. By recognizing that food losses may occur after food production in the country but before reaching households for actual consumption, the new estimate of the Dietary Energy Consumption (DEC) is obtained by taking into account food losses occurring during distribution.

- Preliminary estimates of the incidence of food losses occurring during distribution at the retail level were based on the finding of an FAO study published in 2011 (Gustavsson et al, 2011). According to the published figures on the quantitative incidence of losses occurring at each stage of the value chain by food group, caloric losses are estimated at an average of about 3% of DES, with difference by year and by country due to the different composition of the aggregate food supply. Preliminary estimates for the most recent years were no longer obtained by modeling scenarios in terms of income growth. Projections were obtained of food supplies in each country in the periods 2010-12, based on data FAO uses to produce Commodity briefs. The new projected DES were used together with the parameters (CV, skewness and MDER) used for the assessment of the 2007-09 period, on the account that these other parameters' changes would have a more limited impact on the PoU measure.

Second, household level caloric availability was revised using a new statistical model to estimate the population distribution of food consumption. This replaces the Log-Normal distribution with the Skew-Normal distribution to give more flexibility in capturing changes in the symmetry of the distribution.



Finally, to improve estimation of the distribution's parameters, correction is made for excess variability due to the presence of outliers and to recording food acquisition rather than food consumption data.

4. Next Steps

The revisions completed in 2012 are only the first step into constant efforts to improve the data base and the methodology to measure food insecurity. Most importantly, it was concluded that the PoU needs to be integrated with other indicators aimed at capturing the other dimensions of food insecurity. Failing to do so in the past, in fact, has had the consequence that the PoU has been either over interpreted, or criticized for failing to capture dimensions that it was never intended to capture.

Inspite of the criticisms, it is strongly believed that the PoU remains a fundamental component of any food security information system at country level, and it is recommended that it will continue to be used to monitor progress towards the hunger targets set with the WFS and the MDG. To make sure that this is done properly, many improvement have been implemented, but clearly still more needs to be done. The most critical steps that still need to be made are discussed next.

4a. Better data on food losses

Consideration of food losses occurring during distribution has shown the relevance of the issue. Assessment thus far, however, has been based on the results of a rather general survey, conducted at regional level only, and with reference only to the most recent situation. Data on the incidence of distribution food losses need to be revised on a country-by-country basis, and validated by relevant national statistical authorities.

4b. More data on food consumption

We know that nationally representative household surveys that collect some information on food consumption are being conducted more frequently in many countries. Even if they are not designed by monitor food consumption as the main objective, they can nevertheless provide crucial information for food security, provided the data is appropriately processed.

FAO needs to collaborate as closely and as intensely as possible with the authorities that are responsible for survey design and implementation. Even if these surveys are analyzed by the

responsible organizations and quite detailed reports published, this may not be sufficient to obtain the needed parameter estimates as inputs into the estimation of the PoU. Access to micro data and, most importantly, to the opportunity to discuss with professionals involved in all stages of survey design and implementation, are necessary in order to address issues related to the following: definition of food items; units of measure; conversion factors; reference period for the data collected; number of people in the households sharing the acquired food; how food consumed away from home has been captured; and many other technical aspects that will help in extracting the relevant information contained in the survey.

4c. Improving indirect methods for parameter estimation

From the intense work conducted on the relatively few surveys for which FAO had access tofull micro data, we have learned how to estimate CV and skewness of food consumption for those countries. The next step is to try and understand how these features of the distribution of access to food in the country are linked to other characteristics, such as relative food price level, income level and distribution, and other indicators related to undernourishment (e.g. children mortality rates, prevalence of stunting and wasting). Establishing these relationships will help fill the gap associated with the fact that not all countries conduct large nationally representative surveys annually. CV and skewness of the distribution of food consumption could be updated in years without surveys using other information on the conditions of development.

5. Conclusions and recommendations

In conclusion, there are several actions that FAO member countries in general, and AFCAS countries in particular, may wish to take to improve our collective capacity to monitor food security effectively, and in comparable ways across countries.

The first recommendation is to create more opportunities for exchanging views and data on food security assessment. This includes the possibility to access the micro data from household survey data, and work together with the agencies that have collected the data, to be able to identify possible data issues (unit of measurements, nutrient content, food away from home, etc.)

The second recommendation is for countries to work in collaboration with the relevant international initiatives that attempt at harmonizing standards and tools used when designing and implementing household surveys, such as the International Household Survey Network (IHSN). This is an initiative established under the lead of the World Bank Research Group, which aims at coordinating the diffusion of common standards for designing, implementing and presenting data

from household surveys. FAO actively collaborates with the IHSN, including on defining an optimal module for collecting food consumption surveys for food security analysis.

The final, and more general, recommendation is to address the need to reach agreement on common statistical standards and tools. In the area of food security statistics, for example, agreement could be sought for:

- the methodology to compile FBS;
- the data processing principles and methods for food security analysis; *and*
- adoption of common tools, such as the ADePT Food Security Module.

References

FAO (1996) The Sixth World Food Survey. Rome, FAO

FAO, (2003) Measurement and Assessment of Food Deprivation and Undernutrition. Proceedings of the International Scientific Symposium convened by the Agriculture and Economic Development Analysis Division in Rome, 26-28 June 2002.

Gustavsson, J., Cederberg, C., Sonesson, U., Van Otterdijk, R., & Meybeck, A. (2011). Global food losses and food waste. Rome, Italy: Food and Agriculture Organization of the United Nations.

Naiken L. (2003) Keynote Paper: FAO methodology for estimating the prevalence of undernourishment, in Measurement and Assessment of Food Deprivation and Undernutrition. Proceedings of the International Scientific Symposium convened by the Agriculture and Economic Development Analysis Division in Rome, 26-28 June 2002.

Osmani, Siddiqur R. (1992) Nutrition and Poverty. UNU-WIDER Studies in Development Economics. Clarendon Press, Oxford

Smith, L. C., Harold Alderman and Dede Aduayom (2006) "Food Insecurity in Sub-Saharan Africa. New Estimates from Household Expenditure Surveys." Research report 146. International Food Policy Research Institute, Washington, D.C.

Svedberg, Peter (1999) "841 Million Undernourished?" World Development Vol. 27, No. 12, pp. 2081-2098