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Estimation of undernutrition and mean calorie intake in Africa for 2005: methodology, findings and implications

by

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Abstract

Poverty and hunger are basic yardsticks of underdevelopment and destitution. While the measurement of poverty through surveys is relatively well documented in the literature and a reasonable degree of methodological consensus has been emerging, for undernutrition, information is much scarcer, particularly regarding adults, and very different methodologies are applied for children and adults. Undernutrition in children is generally estimated on the basis of direct anthropometric measurement (underweight, stunting, and wasting) but for adults a headcount is commonly used for instance by FAO that relies on estimates of the "food gap" – the difference between actual and normative calorie intake – in which anthropometry hardly plays any role. To obtain this food gap, food availability, measured as production plus net import at national level, is distributed among household groups on the basis of information from household expenditure surveys. This yields food availability by household group, and comparison with a given minimum calorie intake leads to the gap, from which the headcount is derived. Our paper seeks to improve on this practice in two ways. One is that we estimate the prevalence of undernutrition in Sub-Saharan Africa (SSA) based on anthropometric data for women and children in the Demographic and Health Surveys (DHS), nationally representative surveys commissioned by USAID that have been held in many African countries. As second contribution, we estimate mean calorie intake and implied calorie gap for SSA, also using anthropometric data in the DHS as point of departure, after conducting a test on their quality. Our main results are, first, that we find a much lower prevalence of hunger, and, second, that there is much less spread in mean calorie intake across the continent than reported by FAO (2008), the only estimate that covers the whole of Africa. On the basis of our results, we argue that these spatially explicit estimates of total calorie intake form a solid basis for an assessment of economic performance of Africa. Especially in East and Central Africa, economic growth must have been higher than is usually assumed. In addition, we indicate how our anthropometry-based estimates for the year 2005 can be used in a fast update procedure to assess the impact of the food crisis (2007/2008) on Ethiopia.

Keywords. MDG, food crisis, Sub-Sahara Africa, nutrition, DHS surveys

1. Introduction

The international debate on strategy to fight poverty and hunger very much relies on headcounts of people below a certain poverty line and people below given nutritional standards. However, the evidence and methodology these estimates are based on differ much between both yardsticks. For poverty, several agencies have for many years been engaged on a regular basis in collection and compilation of household surveys in support of progress at national and regional level. Trends are often reported on through poverty maps[1]. In addition, a poverty gap is estimated as indicative of the resources needed to bring the entire population above the defined poverty line. On the methodological front, the main challenge is to combine these survey data with other sources such as population density maps and census information, to obtain estimates with a national coverage (see e.g. Elbers et al., 2003; Davis, 2003).

For estimates of the nutritional status of people, the situation is less favorable. Even though many, usually small-scale surveys have been collected for specialized research, few sources are accessible that provide internationally comparable data on nutritional status. In fact, for Africa, such data are available only for young children and women of reproductive age in the Demographic and Health Surveys (DHS, commissioned by USAID). These surveys have a nationwide coverage, and are widely used to assess the nutritional status and development of children (UNICEF, WHO[2]), but not that of adults. For national headcounts of undernutrition the international community relies on an indirect measure developed by FAO (FAO, 2008). This measure is obtained by distributing food availability, measured as production plus net import at national level, among household groups on the basis of information from household expenditure surveys. This yields food availability by household group, and comparison with a nutrition standard, a minimum calorie intake, leads to the gap, from which the headcount can be derived. The method has been criticized for being unnecessarily indirect and sensitive to assumptions (Svedberg, 1999; Nubé, 2001, Klasen, 2006). In addition, its headcount and is food gap are computed at national level only. Consequently, it is unable to pinpoint the "hunger hot spots" where policy interventions, possibly including food aid, may be required, and to relate the problem to local conditions.

A recent study by IFPRI (2006) has used Household Expenditure Surveys (HES) for the estimation of the prevalence of hunger and the food gap. Based on data for 12 countries in Sub-Saharan Africa (SSA), IFPRI concludes that their estimates of hunger are more closely correlated with measures of poverty than those presented by FAO. While FAO's estimates are based on national food production estimates (supplemented with information on imports, withdrawals from stocks, etc and distribution of expenditures), the HES used by IFPRI provide direct estimates of household food consumption on the basis of actual amounts of food (bought and home produced). With respect to national per capita food consumption differences are pronounced, but of varying signs across countries. Although the direct use of anthropometric data as a measurement of wellbeing is widely spread (especially data on children with respect to weight-for-age, height-for-age, and weight-for-height), comparing anthropometric data with other measures for poverty is much less common. Micklewright and Ismail (2001) explore the potential of anthropometric data of children in guiding the allocation of funds for social assistance from the central government to local communities in Uzbekistan and conclude that such data could be a good guideline for policy makers. Sahn and Stifel (2003) use data on child health and nutrition to validate a new approach

[1] for an overview of applications and methodology, see the poverty mapping webpage of the World Bank: http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTPOVERTY/EXTPA/0,,contentMDK:20219777~menuPK:462078~pagePK:148956~piPK:216618~theSitePK:430367,00.html

[2] See e.g. the global database on child growth and malnutrition, http://www.who.int/nutgrowthdb/en/

to measure income via assets and find that an index of assets indeed outperforms expenditure data in its correlation with these indicators and hence advocate the use of such an index as a means of mapping economic data to information on health and nutrition. A more common link is that between *nutrition* and poverty, e.g. through the definition of poverty lines, among other things used to provide poverty maps, spatially specific overviews of the prevalence of poverty.[3] Following Ravallion (1994), the "food" poverty line is the level of expenditures that is needed to obtain a certain minimum amount of calories, usually 2100 Kcal per person per day at household level. An obvious problem in measuring poverty this way is that this minimum amount of calories can be reached by very diverse diets, with different implications for costs (e.g. see Pradhan et al., 2001), but a less obvious issue is how much calories are actually needed to ensure an intake of 2100 Kcal per person on average in the household as household waste and processing losses are difficult to estimate. This also implies that a reverse inference (what is the nutritional status of the poor given their income and expenditure) may be very difficult and requires much more information than usually contained in household expenditure surveys.

The lack of data and the differences in outcomes obtained from various methods make it all the more essential to make full use of all information available. In this connection, this paper aims at making two contributions: first, we develop for the year 2005 an estimate of the total number of undernourished in Sub Saharan Africa, based on anthropometric information available for women and children in the DHS surveys at province and district level. These surveys cover 48 of the 50 countries in SSA. In our estimate for the year 2005, 33 DHS surveys were used, complemented with data from WHO.[4] Our methodology for estimating undernutrition among adults closely follows the generally accepted method to estimate this number for children. It needs some additional assumptions though, because data are scarce or lacking for male and for adults in particular age brackets, or for particular countries. Yet, we provide evidence suggesting that our estimates for adult undernutrition are not much less reliable than the widely accepted estimates for underweight children.

The second contribution of the paper is to estimate mean calorie intake at sub-national level, based on recorded weights of women and children in the same surveys. Since the DHS data are usually reported at the district or province level, our estimate of the food gap is at the same geographical level and hence far more explicit than the national totals presented by FAO (2008). Furthermore, we show how the estimates of calorie intake also provide some link between nutritional science and economics, since all that is consumed must either be imported, or produced within the country itself. In this respect, we reverse the methodology followed by e.g FAO (2008), in that we infer agricultural production (and hence, agricultural income) from anthropometrically-based consumption estimates.

Since our methodology relies so much on anthropometric data taken from DHS surveys, we also include a discussion on the quality and representativeness of these surveys, an exercise that, to our knowledge, has not been done before, despite the widespread use of this source for the monitoring of children's nutrition and health.

Clearly, our estimates of calorie intake for 2005 might somewhat be outdated, particularly because in 2007/2008 a food crisis occurred. More generally, it uses anthropometric data that are not collected every year throughout the continent. Monitoring of progress made in combating hunger needs regular intermediate updates. To this effect, we supplement the methodology with a fast estimate that updates the 2005 information based on more limited recent data, and provide as an illustration an assessment of the impact of the food crisis in 2008 for Ethiopia.

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[3] for an overview of applications and methodology, see the poverty mapping webpage of the World Bank: http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTPOVERTY/EXTPA/0,,contentMDK:20219777~menuPK:462078~pagePK:148956~piPK:216618~theSitePK:430367,00.html

[4] Only for Angola, use was made of other data, namely WFP (2005a)

Overview

The paper proceeds as follows. In section 2, we describe our methodology to estimate undernutrition on the basis of anthropometry, and we present our estimates in relation to other studies. Section 3 discusses how calorie intake is estimated, starting from bodyweight as key anthropometric variable, presents the results and discusses critical steps in the estimation procedure. Section 4 discusses the reliability of the main source of data, the DHS surveys. Section 5 focuses on the implications of the estimates for agricultural and non-agricultural income and presents an update to assess the situation in 2008 in Ethiopia. Section 6 concludes. Appendix A gives technical background on the calculations, and Appendix B provides background material on the nutrition surveys.

2. Estimating undernutrition prevalence in Sub Sahara Africa on the basis of anthropometry

2.1. Methodology

When all necessary anthropometric data are available, estimation of undernutrition is relatively straightforward but this is seldom the case. As a rule, various assumptions have to be made to fill data gaps, especially for males, adolescents and the elderly as DHS surveys only report on the nutritional status of children and adult women[5].

For children under five, we use the direct results from the DHS-surveys on the prevalence rates of children with a low weight-for-age (2sd below norm weight). For this group, in some surveys data are only available for children of 0-3 years instead of 0-5 years. For countries where this is the case, the underweight prevalence rate in the 0-3 years group has been used, as the ratio of the percentages underweight children aged under 5 years to aged under 3 years is generally very close to one (Nubé and Sonneveld, 2005).

For children 5-10 years of age we take underweight prevalence to be equal to the 0-5 years age group. Few anthropometric data are available to substantiate this assumption, but for four African countries (Madagascar, Ethiopia, Zimbabwe and Lesotho), the underweight prevalence rates in the 0-5 years and the 5-10 years age group have been reported to be rather similar (Hardenberg, 1997; James et al., 1999; Jooste et al., 1997).

With respect to the undernutrition prevalence in the 10-15 age group, there is no universally accepted method for the measurement of undernutrition (WHO, 2005, 2006). Most commonly used indicators are thinness, measured as the percentage of the population with a BMI-for age below the 5^{th} percentile of a norm BMI-for-age, and stunting, measured as the percentage of population with a height-for-age below the 3^{rd} percentile of a norm height-for-age (WHO, 1995)[6]. Both indicators may yield significantly different results, also varying by age, largely because adolescence is a period of rapid growth and rapid changing body composition. As no representative data on undernutrition among the 10-15 year age group are available (DHS-surveys do not cover this age segment), we take the undernutrition prevalence in the 10-15 years age group of a particular country to be the same as the one in the 15-20 segment reported in DHS-surveys.

Next, for the age bracket of 15 years and older, we rely on the measurements for women from the DHS-surveys, supposing that there are no major differences in nutritional status between males and females, except for the countries in Southern Africa, since for South Africa and Swaziland, whose DHS surveys separately record men's weights, the nutritional status turns out to be worse for men.[7] For other regions of Sub Saharan Africa the DHS surveys do not record the nutritional status of adult males, and such data are generally quite scarce. Yet, on the basis of a limited number of small-scale studies, it can be argued that for West, East and Central African countries the difference between prevalence of underweight among adult males and adult females tends to be very small, in terms of mean BMI the males about one point below the females (Nubé

[5] For children, we use the new growth reference data (WHO, 2006b), which are based on new growth studies in children from well-to-do families in various parts of the world, and hence use the reinterpretation of the data in the DHS surveys by WHO.
[6] Recently, WHO has revised its growth reference for the age group 5-19 years, with the objective to bring the growth standards in accordance with the new WHO Child Growth Standards (0-5 years) (WHO, 2007; de Onis et al, 2007).
[7] This finding was also confirmed in personal communication with Joyce Luma, Chief Vulnerability Analysis and Mapping Unit, WFP, Rome.

and Van den Boom, 2003). We consider the available data to be too limited to warrant the assumption of a lower BMI for men in these three regions.

For elderly people, we use the undernutrition prevalence rates as reported for adults. This might cause some underestimation of the total number of persons suffering from undernutrition, as the tendency has been reported of a less favorable nutritional status in this age group (Zverev and Chisi, 2004; WHO, 2008a). Nonetheless, we find the empirical evidence insufficient to justify a separate prevalence rate. We may note that in this class the less favorable condition generally does not develop before the age of 60, which in particular in low income countries only constitutes a small segment of the population.

Finally, for countries without any complete and relatively recent DHS survey or other reliable source of information on undernutrition prevalence, we impute the missing data by borrowing from countries that are close in the Human Development Indicator for 2005. Countries that are closest in general living standard are identified, and the undernutrition prevalence rates of these countries are applied. See Appendix A for the full list of inferences made and procedures applied.

Figure 1 shows the distribution over SSA of DHS surveys used in the estimates for 2005 and the year for which the data are available. Table 1 lists the other sources of data used, in this study, both for estimation of undernutrition discussed here and for the estimation of calorie intake to be discussed in the next section.

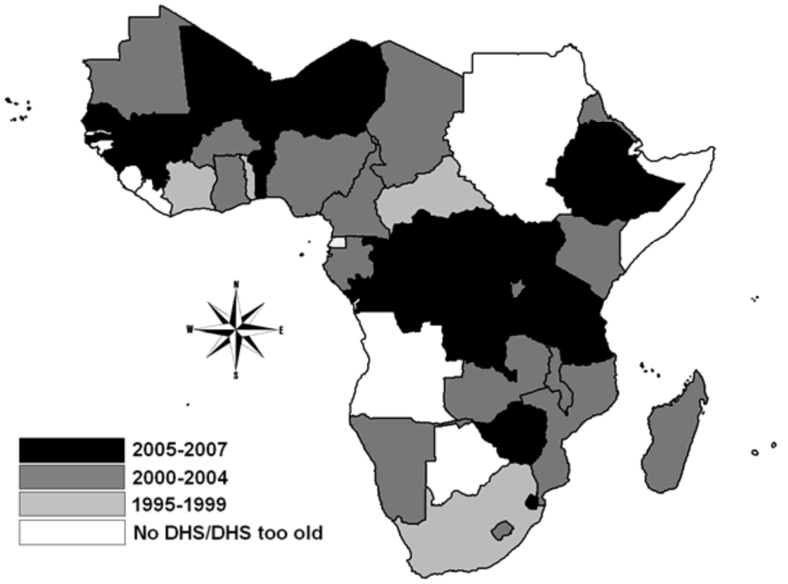

Figure 1. DHS surveys used in estimates for 2005

Table 1: Overview of data sources other than DHS survey reports

	Survey reports	Census	Technical coefficients
Data set	WHO reports on child nutritional status, from DHS surveys	Population tables	Human Energy Requirements
Origin	WHO/USAID	Population Division UN	FAO/WHO/UNU Expert consultation 2001
Country coverage	46 countries	48 countries	----

Time series	1995, 1996, 1998, 1999, 2000, 2001, 2003, 2004, 2005, 2006, 2007	1985, 1990, 1995, 2000, 2005	-----
Variables	Percentage of underweight and severely underweight children (2006 revision)	Population numbers by sex and age	Calorie needs by sex and age related to weight and PAL factors

2.2. Estimates of undernutrition

Using the procedure described above, we arrive at an estimate of 131 million people (all age groups combined) suffering from undernutrition. Table 2 provides the estimates for the four subregions and the total, and also shows the estimates for 5 individual countries for which estimates from other sources are available for comparison. FAO (2008) estimates that in SSA as a whole 212 million people were undernourished in the years 2003-2005. This figure is obtained starting from the per capita availability of calories for consumption of the Food Balance Sheets mentioned earlier, and assuming a distribution of the available calories over the population based on household budget surveys (FAO, 2003). IFPRI (2006) estimates, based on Household Expenditure Surveys, are available only for selected countries and in all cases the estimates are even higher than those of FAO. However, WFP (2005b, 2006a,b) estimates based on independent surveys, come very close to our figures.

Table 2: number of undernourished in millions in 2005, regional totals and selected countries

Region	*Own estimates*	*FAO (2008)***	*IFPRI, 2006*****	*WFP (2005b, 2006a,b)*******
Western Africa	43	34		
Central Africa	20	61		
Eastern Africa	65	114		
Southern Africa	3	1		
Total Sub-Saharan	131	210		
Ethiopia	22	35	56	
Senegal	1	3	5	
Tanzania	5	13	17	4
Uganda	4	4	10	3-4
Niger	3	4		4

*Country totals aggregated to match region definition, **Percentages referring to 1999 (Ethiopia, Uganda), 2000 (Tanzania) and 2001 (Senegal) are applied to 2005 population totals, ***percentages are applied to 2005 population totals

Regarding our DHS-based estimate of 131 million, we recall the earlier qualifications that for adult men, and women in some age groups, such as the adolescents and the elderly, data availability is limited. Hence actual prevalence rates of undernutrition in these groups might be different and possibly higher than our current estimates, notably for men, children aged 5-9, youth aged 10-14 and elderly above 60. Therefore, we also conducted calculations of the total number of undernourished under adverse assumptions on the prevalence of undernutrition in these groups.

Since the elderly (above 60) on average only comprise between 3.5 and 6 percent of the population, varying assumptions on this age group have a very limited effect on the aggregate:

even if we assume that the BMI for this age group (now estimated to be 22.3) was as much as 1.5 points lower on average, the increase in the number of people classified as being undernourished would only shift by 5.2 million.

For children aged 5-9, we recall that we have taken the prevalence of underweight children to equal that of the group aged 0-5. For the total group of children (0-9), this implies that 54 million children are undernourished, of which a share of 36% is between 5 and 9 years of age. Even if we assume that the prevalence of underweight children is 25% higher than in the age group 0-5, this only leads to an increase of 5 million children.

For the age group of 10-14, we assumed that the nutritional status is equal to that of the group 15-19. Potentially, classification errors for the age group 10-14 could have large effects, since this group comprises on average some 12.5 percent of the total population. Here we can use additional information that is available on the distribution of BMI over the population to assess the number of people that would be classified as being undernourished if the average BMI of this group would be lower than under the current assumptions made. If we assume that the BMI is overestimated by 0.5, 1.0, or 1.5 points, the total number of people classified as suffering from undernutrition increases by 3.8, 7.6, and 11.3 million people, respectively.

For men, the only available data are for Swaziland and South Africa, where the difference between the percentage of adult males and females with a BMI lower than 18.5 is 7.5 percentage points. If we assume that also for West, Eastern and Central Africa, this is the true distribution of undernutrition by gender, then this would add another 17.9 million undernourished men to our estimate.

Summarizing, our sensitivity checks indicate that even if for adult men and all three age groups we have severely underestimated the prevalence of undernutrition, the total number of people suffering from undernutrition (170 million) would still be 40 million lower than the FAO (2008) estimate of 210 million. Since the population composition does not differ significantly between the four regions in Sub Saharan Africa, it is very unlikely that even severe errors for specific groups would lead to changes in the regional pattern of undernutrition and consumption. Hence, the picture of Africa that emerges from our calculation is more positive than what emanates from FAO estimates. Yet, it is clear that a too narrow focus on undernutrition as recorded in surveys might obscure the grim reality of what is not recorded.

2.3. Discussion: child mortality and refugees

One of these hidden factors is child mortality. On this front, a definite lack of progress has to be deplored in SSA. Children who died no longer appear among the hungry. The under-five mortality in SSA in 2006 is estimated at 160 per 1000 live births against 187 in 1990 (UNICEF, 2007). Here SSA strongly lags behind other developing regions, both in absolute numbers and in terms of progress made. The many endemic diseases, poor quality of drinking water, stronger climatic variability leading to crop failures, possibly also different quality or accessibility of health services are often mentioned explanations.

In addition, because of a larger share of the farm population in total, and limited availability of domesticated animals, largely due to prevalence of animal diseases, most farmers have to cultivate with human power only. Consequently, adults have to be relatively fit and hence well off in nutritional terms, possibly at the expense of children, particularly the weaker ones who are deemed less productive in future farm work. By the same token, however, any decrease of child mortality would, at present birth rates, immediately result in a much higher demand for food, since, as is well-known, birth rates only drop gradually in response to a decrease in child mortality (see e.g. Kuznets, 1966), hence worsening the nutritional status of the population as a whole, unless intensive family planning is implemented to manage the necessary demographic transition.

Another hidden factor is the persistent refugee problem in SSA, since these people are not captured by the anthropometric surveys discussed. For the year 2005, UNHCR estimated the total number of people of concern to the UNHCR in SSA to be around 5.2 million, some 1.7 million of which are refugees in camps who are largely dependent on food aid.

Finally, the food aid delivery by foreign donors reduces the level of observed malnutrition: in 2005, roughly 8 million tons of cereal equivalents were distributed within Sub-Saharan Africa. This is equivalent to 31.5 million people on a full ration, or, if on average all beneficiaries receive 1000 kcal/day, to 66 million people.

Be this as it may, these qualifications also apply for the widely accepted anthropometric indicator of child malnutrition, and the reliability of our estimate of total undernutrition therefore is no less than that for the children.

3. Estimating calorie intake in Africa

3.1. Methodology

Having argued and documented that direct measurement of undernutrition in children and adult women can offer a relatively reliable basis for estimating undernutrition among the overall population, we are now ready to move to the next step, which is to estimate average calorie intake among the population, in particular the prevailing calorie deficits.

This obviously is not an aim in itself. The anthropometric measures discussed so far only describe the end result of the nutrition chain. To understand how this result came about it may be useful to track it back to the information on food production and distribution. This makes it possible to assess the trends in terms of economic performance, growth and development, an aspect we return to in section 5. In addition, by tracing the demand implications of a particular anthropometric status by subregion and age group and by sex, it becomes possible to build up estimates of food deficits from its constituent parts, with possible implications for food aid needs. Finally, calorie consumption plays a pivotal role in FAO's estimates of undernutrition and comparing our findings on this variable may reveal causes of differences in estimates of undernutrition prevalence.

Clearly, the procedure will involve several steps, from anthropometry - in particular actual weight - via physical activity level of the individuals concerned, to their nutritional intake that is biophysically associated to this weight. We calculate in parallel the nutritional intake needed under the prevailing activity level to provide adequate nutrition and from this obtain the food deficit of a particular group. Summation yields the average calorie intake as well as the overall food deficit.

Hence, the weight and length of individuals as recorded in the Demographic and Health Surveys (DHS) provide the anchor for our estimation of calorie intake. In addition, we use anthropometric data from other sources. The basic nutritional insight enabling us to establish the link between anthropometry and calorie demand is that that there exists a strong biophysical relation between the weight of a person and the calorie intake that is needed to sustain this weight. This relation is usually invoked only to determine a recommended level of calorie intake but our estimation of actual calorie intake uses it in reverse direction: if a person has a certain weight, then this implies that the calorie intake must have sustained this weight during the period preceding the measurement, given specific allowances for physical activity (adults in general), for growth (children), and for pregnancy and lactation (women).

For all age groups and for both sexes, relations between weights and calorie intake, with physical activity levels and birth rates as parameters, are estimated and published in FAO (2004b). The general structure of the relations is as follows (for notational convenience, a regional subscript is omitted):

$$cal_{g,t} = \begin{cases} A_{g,t} + b_{g,t} * weight_{g,t} - c_{g,t} * weight_{g,t}{}^2 + growth_{g,t} & \text{for age groups 0-17} \\ (b_{g,t} * weight_{g,t} + A_{g,t}) * PAL_{g,t} & \text{for age groups 18+} \\ (b_{g,t} * weight_{g,t} + A_{g,t}) * PAL_{g,t} + c_{g,t} * RATE_{g,t} & \text{for women in fertile age groups} \end{cases}$$

where the subscript g denotes gender and t denotes age; $cal_{g,t}$ is the calculated daily calorie intake by age and gender, $weight_{g,t}$ is the measured weight of the person, $growth_{g,t}$ is a parameter representing allowance for growth; $A_{g,t}, b_{g,t}, c_{g,t}$ are other given parameters, $PAL_{g,t}$ is the Physical Activity Level correction factor, and $RATE_{g,t}$ is the birth rate by age group for women in fertile age groups. Hence, all coefficients are gender and age specific.

National figures for birth rates are obtained from FAO (2004b), and supposed to be equal for all women in the fertile age groups. This is a simplification, of course, but it may be warranted as we only use the figures to calculate nutritional requirements of mothers, as opposed to the births themselves. Growth allowances and values of the parameters $A_{g,t}, b_{g,t}, c_{g,t}$ are taken from FAO (2004a).

The survey information used contain data on the weight of women, as well as on the percentage of children aged 0-5 (or 0-3, see section 2.1) that are underweight, measured as having a weight below 2 sd (standard deviation) of the norm for their sex and age group (see Appendix A for the availability of DHS surveys by country and year). Hence, whereas for women weights are observed directly, for children we only have data on the percentages of children from 0 to 5 years of age that are underweight (2 sd below norm weight) and severely underweight (3 sd below norm weight). For this age group we calculate the average weight as follows:

$$weight_{g,t} = (1 - sd_2) * \beta * w_{g,t} + (sd_2 - sd_3) * \hat{w}_{g,t} + sd_3 * \tilde{w}_{g,t},$$

where $weight_{t,g}$ is the calculated average weight of the child, sd_2, and sd_3 are the shares of children with weight below 2, respectively below 3 standard deviations of the norm weight for their age, and $w_{g,t}$, $\hat{w}_{g,t}$, and $\tilde{w}_{g,t}$ are the norm weight, the weight at 2 sd below norm and the weight at 3 sd below norm, respectively. We note that as these norm weights follow established international standards they are the same for all countries. The factor β, the ratio of the average BMI of the women in the area over the norm of 18.5, adjusts these weights assuming the nutritional status of children that are not underweight to follow that of the mother. For the age group 5-9 years, as in the estimation of undernutrition prevalence (section 2.1), we assume similar rates of undernutrition prevalence as they exist for the 0-5 years age group, and use the same procedure as for the age group 0-5. For female adolescents of ages 10-14 years, weights are based on women of ages 15-19 years, on the basis of the ratios between weights at different ages from FAO (FAO, 2004b).

For men, we use FAO (2004b) that provides estimates of weights of women and men of all age groups for all countries, and apply the ratio of the weight of males and females in the same age group to calculate the weight of the men. Hence as in section 2.1, we abstract from any major differences between men and women as far as nutritional status is concerned. Recalling that in Sub Sahara Africa the nutritional status of females might be somewhat better than that of males, this might result in a slight overestimate of kcal consumption. Since for South Africa and Swaziland, data for men are available directly from the DHS surveys, for these countries, direct estimates of the nutritional status of men are made, and the relative status of men versus women in these countries is used to infer the status of men for the whole of Southern Africa. For the other regions, no correction for the possible difference between men and women was made in view of the lack of reliable large-scale studies on possible differences between adult male and female nutritional status (Nubé, 2006).

Finally, since country surveys are not always available for the common reference year 2005, inference is required and our estimates for energy consumption suppose that there are no major variations within the time span of a few years, in body weight for people within the same age bracket. This assumption is supported by anthropometric data from countries where two or more DHS-surveys have been implemented over the past 10-15 years. In most of these countries, the mean weight of the adult population changes by, at most, 2-3 kg over periods of around 5 years. The amounts of energy (calories) implicated in such changes are in the order of magnitude of 10-15 kcal per day only, and hence remain well within the one percent range for a total per capita energy expenditure of around 1800-2200 kcal.

Another major factor affecting the estimation of per capita consumption by gender and age is the correction for physical activity (see for example FAO, 2004b, for PAL estimates by country). The minimal correction is a factor 1.58 that corresponds to very light activity such as sleeping, sitting, and standing, and increases with the activity level. Section 3.2 below discusses issues related to the choice of the appropriate PAL correction factors. In our calculations, we have used a relatively low PAL factor, to remain on the conservative side regarding calorie intake; PAL factors for urban areas vary from 1.58 to 1.78, whereas rural PAL factors range between 1.58 to 1.8, depending on body weight – if the body weight is very low, we set the PAL at its minimum level, to reflect the fact that malnourished people will tend to adjust their activity level (Borgonha et al., 2000). In general, rural PALs will be higher than urban PALs in the same area, as tasks are usually less demanding physically in urban than in rural areas.

The final step in the estimation of total calorie consumption is the calculation of rural, urban, and national average calorie intake. For this, we use data on the structure of the population by age group and gender, as published by UN (2001, 2002, 2006, 2007).

For countries where no complete, recent, DHS survey is available, we impute the missing data as follows[8]. First, by using the Human Development Indicator for 2005, we identify the countries that are closest in general living standard. Next, we use differences in child weight measured across provinces or districts to arrive at a geographical differentiation of per capita consumption. If in addition to missing survey data on adults, also data on children are missing, we use the country closest in terms of HDI without corrections. The full list of inferences made and procedures used are shown in Appendix A.

3.2. *Estimates of calorie intake*

Using the methodology described above, we arrive at an average calorie intake for Sub Saharan Africa of 2098 Kcal/capita/day. To allow comparison with estimates as presented e.g. by FAO (2008) and IFPRI (2006), we must make a final step from *calorie intake* to food availability. Food availability data refer to all food available for human consumption at retail level. This implies that food wastes occurring at retail level and food losses at household level (including foods given to pets, other animals) are included. Also, food losses that occur in institutions such as hospitals, schools, or the military, are included in estimates of food availability. At household level, in high income countries the total consumption that does not result in human intake runs into the 300-400 kcal per person per day (Jones, undated; Kantor, 1997; WRAP, 2007, Milieu Centraal, undated). Losses at retail level and in institutional feeding are probably larger, but reliable data are not available. As a conservative estimate, we estimate the food wastes at 200 and 100 kcal per capita per day in urban and rural areas, respectively, with a maximum of 10 and 5 per cent, respectively, in total per capita consumption. Under this assumption, Table 3 shows the estimates of calorie availability for the four regions, Sub-Saharan Africa as a whole and four selected countries for which IFPRI (2006) estimates are available. For SSA as a whole, our estimates are only 5 percent above those of FAO. However, comparison at regional level shows remarkable differences. In line with our estimates of undernutrition, the situation seems to be much less dramatic, especially in Central and East Africa, than if the FAO figures are used. In contrast, FAO's very high figures of calorie consumption for West and Southern Africa are not

[8] The only exception to this rule is Angola, where we used WFP (2005) as source for the nutritional status of women.

matched by our estimates. On the whole, DHS-based estimates present a picture of Africa that is less diverse geographically. At the country level, a mixed picture emerges in comparing our estimates with those of FAO and IFPRI. For Ethiopia and Senegal, our estimates are well above those of FAO and IFPRI, while for Tanzania and Uganda, our estimates are higher than FAO, but lower than IFPRI.

Table 3: Per capita availability of calories in 2005, regional totals and selected countries

Region	*Own estimates*[*]	*FAO (2008)*[**]	*IFPRI, (2006)*[***]
Western Africa	2321	2518	
Central Africa	2252	1760	
Eastern Africa	2245	1951	
Southern Africa	2618	2858	
Total Sub-Saharan	2297	2184	
Ethiopia	2046	1810	1592
Senegal	2400	2150	1967
Tanzania	2328	2010	2454
Uganda	2399	2380	2636

[*]Estimates of intake corrected for losses.[**]Country totals aggregated to match region definitions. [***]data refer to 1999 (Ethiopia, Uganda), 2000 (Tanzania), 2001 (Senegal)

As mentioned in the introduction, estimation on the basis of DHS data offers the major advantage that the data at province and even district level can be used directly, whereas the FAO-method that proceeds by balancing supply and demand after correcting for imports and exports cannot reach as deep since it does not record the net trade flows between provinces and districts. As an illustration of the geographical spread of per capita consumption across the continent, we present a map of per capita *intake* of calories for West Africa, underlying the numbers for this region appearing in the first column in Table 3 (with the qualification that here no correction has been made for food losses at household level). Figure 2 confirms that policy relevant information can be obtained in this way, here highlighting the North-South division in consumption levels in this region, with high consumption along the coast and lower levels in the North, and the higher consumption in urban areas (viz. Ouagadougou and Yamoussoukrou).

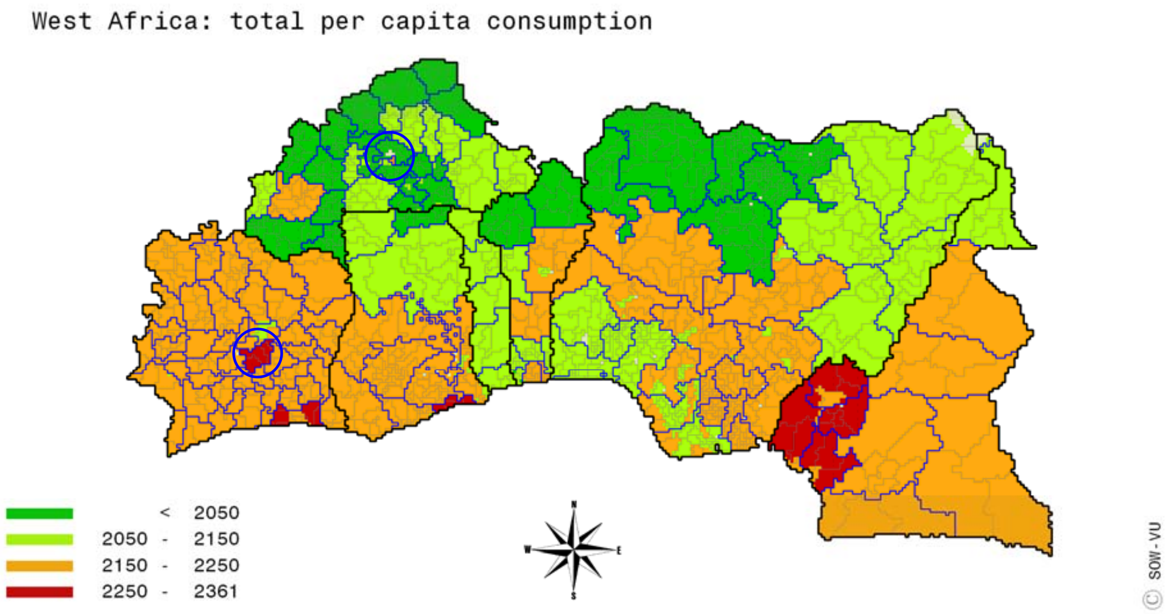

Figure 2: Nutrition map of West Africa, per capita kcal intake in 2005. Source: own calculations

Although it is clearly impossible to discuss results for every country separately, we mention the special case of Mozambique, for which a recent study by Silva (2007) concluded that the per capita consumption for northern districts was higher than that for the southern ones, which came as a surprise even for the author himself. From the DHS data, it follows that the northern districts are in fact, worse off in terms of calorie intake, reinforcing the point that information from another source (i.e. direct anthropometric measurements) can complement and sometimes even highlight possible errors in other surveys.

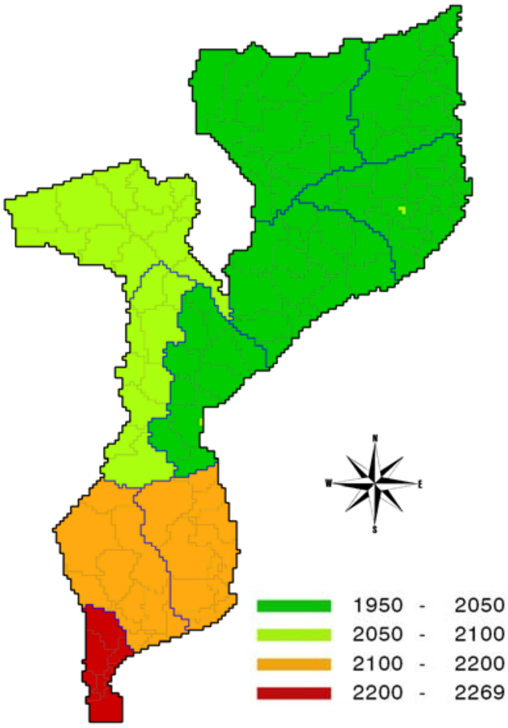

Figure 3. Nutrition map for Mozambique. Source: own calculations

On the analogy of the poverty gap, we can now also compute the hunger gap, as the difference between a normative calorie intake, based on a norm weight (18.5 times the square of the height) and a minimum activity level (the PAL factor is set at 1.58), and the actual calorie intake. The map for Ethiopia in Figure 4 shows that in per capita terms hunger is deepest in Shenile district of Somali Province, in large areas of the Southern Nations and Nationalities Province, and in parts of Amhara, with per capita deficits running between 200 and 257 kcal/day.

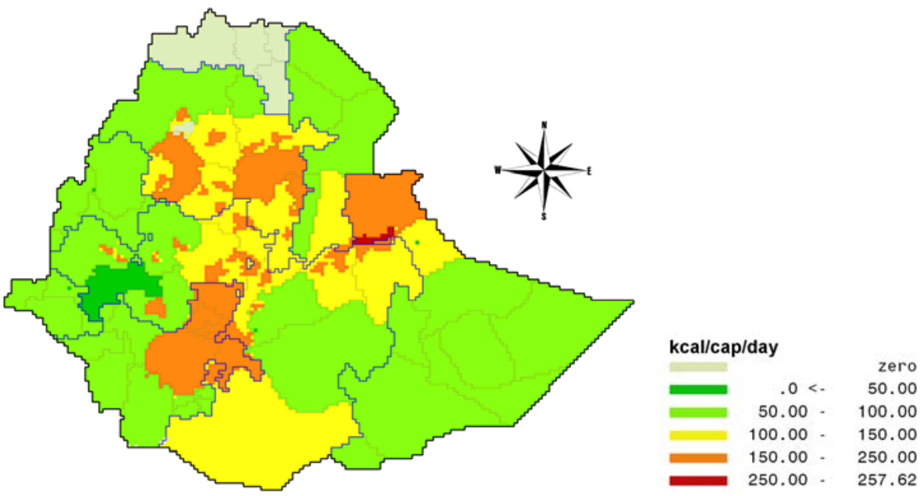

Figure 4: hunger gap map for Ethiopia. Source: own calculations

3.3. Discussion

Apart from the assumptions made on weights and undernutrition prevalence in population segments for which no DHS-data (or other reliable data) are available, some other components in the estimation of calorie consumption need brief discussion. These are the assumed levels of physical activity, and the possible impact of illness on kcal intake.

Physical activity level

In nutritional calculations, the level of physical activity of a person, or a group of persons, is generally expressed by the PAL-value (Physical Activity Level). The PAL is defined as the ratio of the Total Energy Expenditure (TEE) to the Basal Metabolic Rate (BMR) (FAO, 2004a, 2004b). As stated in section 3.1 above, our calculations apply separate PAL values for urban and rural consumers, and take as point of departure 1.58 for urban and 1.8 for rural consumers, following FAO (2004b). In addition, FAO (2004b) provides data on the percentage of the population in a country that is labeled "urban". To reflect this, we corrected the PAL as follows: if the share of urban consumers in total is higher than that reported by FAO, we conclude that in our database the urban areas also include population that the FAO classifies as rural. In this case we increased the PAL factor for the urban consumers relative to the level reported in FAO (2004b) according to:

$$PAL_u = 1.58 * POP_u^f + 1.8 * (POP_u - POP_u^f) / POP_u, \quad \text{for } POP_u > POP_u^f$$

$$PAL_u = 1.58, \quad \text{for } POP_u \leq POP_u^f$$

Where POP_u^f is the urban population implied by FAO (2004b), POP_u is the urban population in our own database, and 1.58 and 1.8 are the PAL factors for urban and rural areas, respectively, as given in FAO (2004b) for all countries considered here. For rural areas, we start from the PAL factor of 1.8 for all rural consumers as reported in FAO (2004b) and correct this value downwards if the bodyweight is low.

There are various methods for empirically assessing the total energy expenditure of individuals or groups of individuals. The traditional ones include collection of detailed information on total daily food consumption by households say, from food expenditure surveys, followed by a conversion of the various foods into calories. This approach tends to suffer from high error margins because of poor recording of both the acquisition of food and the food intake during meals. Two other methods for estimating total energy expenditure are generally considered to yield reliable results. The first, and probably most reliable method, is the measurement of total energy expenditure with the Doubly Labeled Water method (DLW; FAO, 2004a). The second method, also increasingly applied, is the Heart Rate Monitoring method (HR; Kurpad et al., 2006).

While both the DLW- and HR-methods are mainly applied in research in industrialized countries, some results have been published for developing countries but mainly in Asia. These studies report for rural settings PAL-values in the order of 1.8-1.9, whereas our maximum PAL-value for rural areas is set at 1.8 (Borgonha et al., 2000; Rosetta et al., 2005; Murayama and Ohtsuka, 1999). For urban settings, the reported PAL values are in the order of 1.6-1.8, which is also higher than the PAL-value of 1.58 used here for fully urbanized population groups (Borgonha et al., 2000; Yamauchi et al., 2001; Yao et al., 2002; Spurr et al., 1996). It should be mentioned that most of these studies limit their measurements to small samples of persons. Nonetheless, when compared to the data available for developing countries our assumed PAL-values fall in the lower end of the range, indicating that our estimates of calorie consumption may be on the conservative side.

Illness and calorie intake

Illness is another factor that might affect food intake, and given the wide spread of illnesses among children and adults in Africa, questions may be asked about the effect of these diseases on total food intake. Among nutritionists, consensus is emerging that the energy requirements of sick patients are usually similar to or lower than those of healthy subjects (Elia, 2000). The reason is that possible increased metabolic calorie requirements caused by the disease are generally more than offset by a reduced level of physical activity.

A very crude quantitative estimate of a possible reduced level of food intake, for example as a result of the aids epidemic can be made on the basis of (few) published results on food energy consumption and PAL-levels of aids-patients (Sheehan and Macallan, 2000). According to a review by Elia (2005), PAL-values of patients with HIV/AIDS vary between 1.3 and 1.7, depending on the phase of the disease, with an average PAL-value of approximately 1.5. Yet, the effect of this reduced PAL-value on total kcal consumption at population level will still be rather limited. For the PAL-value of the healthy segment of the population estimated at 1.8, and assuming that 10% of the population has a reduced PAL of 1.5 as a result of illness, the total resulting average PAL will be 1.77, which is a reduction with about 1.5%.

Furthermore, it may be noted that, apart from being associated with a lower level of physical activity, a reduced food intake due to illness may also cause reduced growth in children or weight loss in adults. However, as our present food consumption estimates are based on actual data on body weight, these effects are in principle already accounted for in our calculations.

4. How representative are nutrition surveys?

Since our methodology so much relies on anthropometric data on women and children from the DHS-surveys, the quality and representativeness of these surveys deserves further discussion before we move to the discussion of the implications of our findings in the next section.

For this, we compare these measurements with those of other independently collected surveys, implemented within the same country or region, during a time period close to or overlapping with the DHS survey.

Such comparison is only possible for anthropometric surveys on children that have been conducted for much longer in many developing countries. For example, since the mid 1990s UNICEF has been implementing, in cooperation with national organizations, the so-called MICS-surveys (Multi Indicator Cluster Surveys), in which also anthropometric data on children are being collected (MICS, 2006). The MICS-surveys resemble those of DHS, but they are generally conducted in full separation from the DHS activities. In some countries, national nutrition surveys are executed often at regular time intervals and sometimes as part of a continuous nutrition monitoring system. Height-for-age is the anthropometric indicator used for this purpose because, unlike weight-for-age and weight-for-height, it is not immediately affected by short-run changes in nutritional conditions.

We only compare countries where anthropometric data are available from surveys three years apart at most, and preferably with shorter time spans between the surveys. The prevalence rate of children with a low height-for-age is generally reported for either under-five children or under-three children. Hence, when the time span between two surveys is no more than two or three years, a fraction of the targeted population segment (children under five years) will appear in both surveys (albeit through different individuals since are not panel surveys), as children who were one or two years old at the time of the first survey will be three or four years old at the time of the second survey. It is partly for this reason that, in particular for the anthropometric indicator height-for-age, differences between successive surveys can be expected to remain relatively small. Only over longer periods of time, and in regions where undernutrition is widely prevalent, hopefully reductions, significant changes are foreseen to occur.[9] We now report on the comparison in two figures.

Figure 5 compares nutrition surveys held within time spans of generally 2-3 years in 13 Asian countries, with for five countries (Bangladesh, Myanmar, Nepal, Sri Lanka and Vietnam) two sets of data (more complete information on the years of the surveys, the sample sizes, and whether the data are based on DHS-surveys, MICS-surveys, or derived form other sources, is provided in Table B1, Appendix B). The figure shows that out of the 18 comparison sets, in 13 cases the difference between the two survey results is less than 5 percentage points, and in three cases between 5 and 10 percentage points. Only for Pakistan and for one comparison set of Myanmar, the differences between the two survey results exceed 10 percentage points.

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[9] For the comparisons of successive nutrition surveys, in most cases data were available for the same age groups (e.g. two surveys with prevalence of low height-for-age in children under three years, or two surveys with prevalence of low height-for-age in children under five years). For those countries where in two subsequent surveys the reported prevalence of low height-for-age was reported for different age groups (e.g. in the first survey for children under three, and in the second survey for children under five), a correction factor was used, under the assumption that, on average, the prevalence of low height-for-age in children under five years is 1.15 times higher than the prevalence of low height-for-age in children under three years (own calculations).

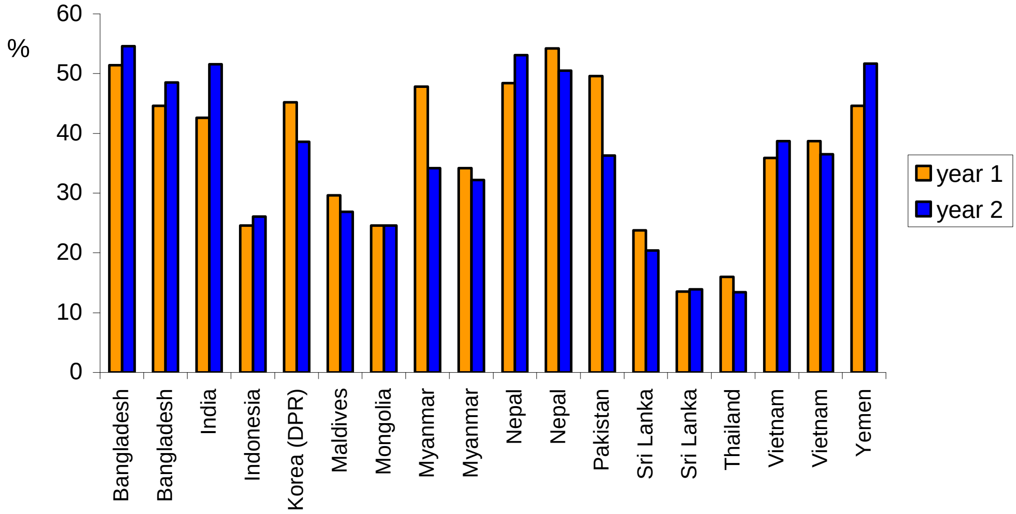

Figure 5. Undernutrition prevalence rates in children (low height-for-age) in sets of two successive surveys for 13 Asian countries (18 comparison sets)

Figure 6 compares surveys for 15 African countries (see also Table B2 of Appendix B). As there are many more DHS-surveys available for African countries than for Asian countries, we limit attention to comparison of cases for which two consecutive DHS-surveys are available or a DHS survey and a non-DHS survey. Here also it appears that for most countries the prevalence rates of low height-for-age as measured in two successive surveys are in reasonable agreement. In eleven comparison sets differences are less than 5 percentage points and in three comparison sets differences between 5 and 10 percentage points. In six cases the agreement between the two successive surveys is much less satisfactory, with differences larger than 10 percentage points. Though these differences might, in principle, reflect actual changes in nutritional conditions, it is more likely that sampling procedures (or even measurement techniques and quality) differed strongly between the two surveys.

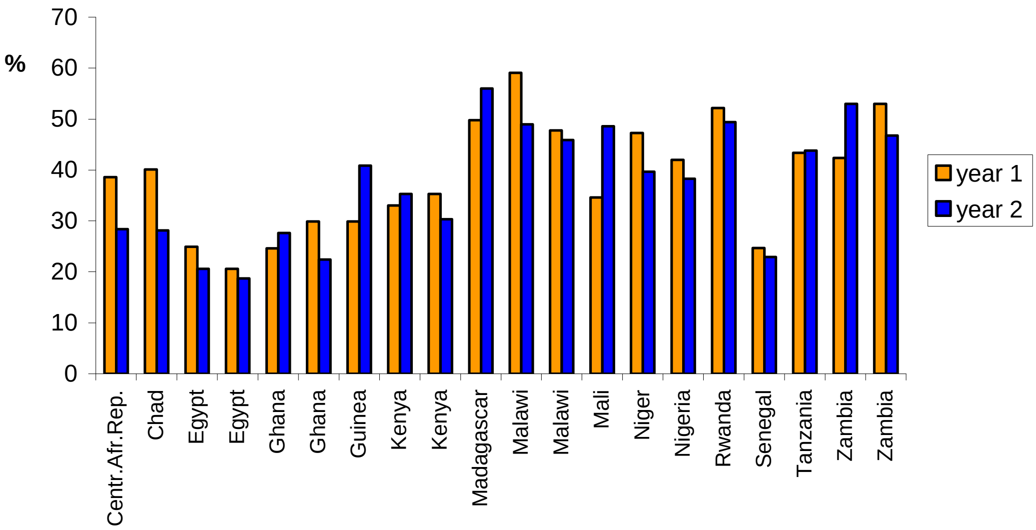

Figure 6. Undernutrition prevalence rates in children (low height-for-age) in sets of successive surveys for 15 African countries

Finally, Figure 7 shows for one country (Zambia) the results of three successive nutrition surveys over a time span of 10 years (1992-2002), hence covering a full change in the cohorts of children surveyed. It appears that also over this longer period of time, the pattern of underweight distribution as measured by height-for-age remains strikingly constant, with only the 2001/2002 results for the regions Central, Copperbelt, and Eastern showing some deviation from the overall pattern.

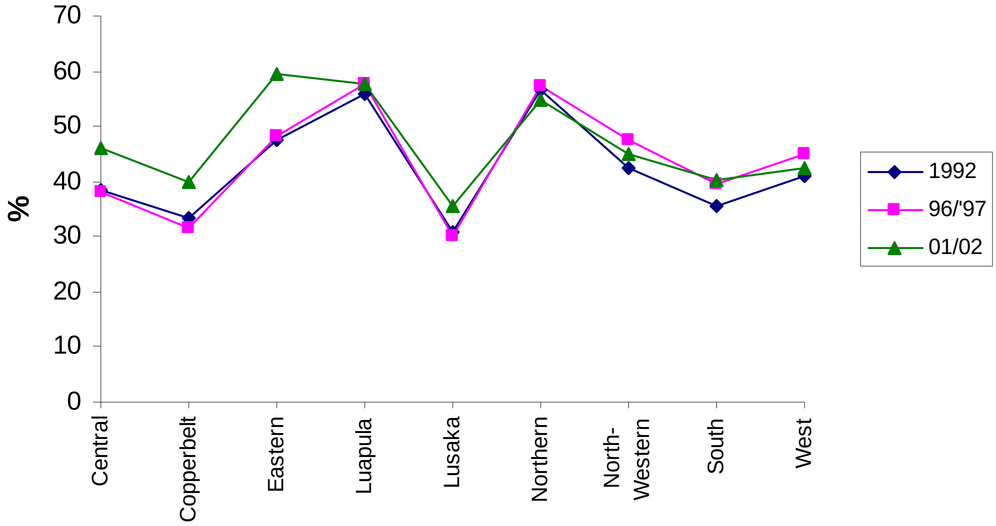

Figure 7. Undernutrition prevalence rates in children (low height-for-age) in the 9 provinces of Zambia, as reported in three successive surveys over a period of 10 years

Summing up, these comparisons indicate that nutrition surveys held within relatively short time spans tend to remain in reasonable agreement. This applies to surveys implemented by one and the same agency, such as DHS, and in most cases also to surveys that were designed and implemented by different organizations. We also we remark that data on child malnutrition as reported in publications by international organizations such as WHO, UNICEF are, particularly for African countries, largely based on results from DHS surveys (WHO, 2008b; UNICEF, 2008), and that these data currently provide the only yardstick actually used for measuring progress in the hunger reduction target under MDG1.

Therefore, we conclude that the DHS surveys, which form an important part of the data sources used in the comparisons made in our study, are widely accepted as a reliable data source and yield results that are reliable and representative at country level. Furthermore, the we have illustrated that the they are likely to provide adequate measures at sub-national level as well.

5. Implications for Africa’s record: from nutrition to economics

5.1. Implications for growth of agricultural and non-agricultural output

Our estimates of undernutrition and calorie consumption project a picture of Sub-Saharan Africa in 2005 that is significantly more favorable than the one generally emerging from reports by FAO and other international agencies. This result is not only important in itself, it also has implications for the estimation of economic growth in Sub-Saharan Africa in the recent past. The present section takes a glance at these possible implications.

First, the hypothesis can be rejected that the situation in 2005 was exceptionally favorable or achieved after a major breakthrough. Leaving aside that there is little a priori reason to suppose this, a comparison of food consumption between 2000 and 2005 confirms this. Using the same methodology as described above and performing the complete exercise for that year, we find for the year 2000 an average calorie intake per capita of 2043 kcal for SSA as a whole, against 2102 in 2005. This improvement in average consumption is largely due to the sharp increase in per capita consumption in Central Africa (up from 1857 to 2052), because of the recovery of Rwanda and Burundi after the end of the war. Hence, the findings for 2005 would indicate that overall food production has kept up with population growth more or less in all regions during the past decade. This would imply that FAO estimates tend to underrate not only the level but also the growth rate of agricultural output achieved in the Central and Eastern regions of Africa.

Second, the outcomes have significant implications for growth outside agriculture as well, especially given the fact that the share of urban population has been rising strongly over the past twenty years[10]. This growing urban population apparently was by and large producing sufficient value added to purchase the implied volumes of consumption.

Third, on average, the estimated urban per capita calorie intake is around 3% higher than the rural one.[11] Bearing in mind that these differences refer to intake only and higher food losses and wastes (higher levels of consumption of processed food, higher food losses in institutions such as hospitals, army, offices, etc.) will generally require higher levels of per capita food availability, the differences between rural and urban availability of food are likely to be even higher.

On the basis of these three considerations we conclude that rural areas must have produced a significant and growing agricultural surplus and, barring significant deterioration in agricultural versus non-agricultural terms of trade, that non-agricultural output must have risen as well, to pay for this consumption.

5.2. Fast updating: the effects of the 2007-2008 food crisis on Ethiopia

An obvious critique on our results is that the base year for our assessment of nutritional status is 2005, i.e. before the onset of the food crisis that reached its peak in the years 2007-2008, when steep rises in food prices severely reduced purchasing power of consumers. Despite widespread concern about these effects, the magnitude of the effects still is a topic of controversy. On the basis of field missions, WFP (2008) estimates the total number of people in Ethiopia that are

[10] In the period 1980-2005, the share of the urban population increased from 24% to 35% for SSA as a whole. For West, East, Central and Southern Africa, this share increased from 27% to 42%, 15% to 22%, 29% to 40%, and 45% to 56%, respectively. (Source: UN Population Division)

[11] As regards differences in average per capita kcal intake in urban and rural settings, literature is not unequivocal, with some studies reporting higher kcal consumption in rural areas and other studies reporting higher kcal consumption in urban areas (Mennen et al., 2000; Glew at al., 2004).

affected at 12.5 million, of which 9.6 million are actually being targeted as food aid recipients. Besides price rises, WFP also lists drought, unrest, and animal diseases as causes of increased malnutrition.

In their worldwide assessment of impacts from the food crisis, Ivanic and Martin (2008) impute the effects of the rising food prices on the real incomes of people, from which they derive the total number of people that have been pushed below the poverty line, the widely quoted number of 100 million people. This estimate is based on a nine-country[12] household survey for which data on consumption and production of the main food commodities are available. Simulations of food price changes between 2005 – 2007 are carried out for the countries in the sample (0% for beef, 90% for dairy, 80% for maize, 15% for poultry, 25% for rice, 0% for sugar and 70% for wheat), with and without an included effect on wages. The average increase in poverty headcount found in the sample (4.5%) is then applied to all low-income countries to arrive at an increase in poverty count of 105 million people.

Here we apply the Ivanic and Martin (2008) approach within a spatial context, to identify the geographic distribution of the "new poor". Our application is for Ethiopia during the period December 2007 – July 2008, based on available date at province level that provide information for a fast update of the nutritional states. Our fast update procedure operates under the following assumptions. First, we choose the province level consumption of 2005 as reference, and assume that until the crisis broke out, that is during 2005- 2007, the total per capita calorie intake has remained roughly constant. Secondly, we calculate the budget share of food in total expenditures at province level in December 2007 from CSA (2008), and also use food price data at province level to impute the price increase of food for the period January 2008 – July 2008. Table 4 shows these data by province.

Table 4: Food budget shares and price increases of food for Ethiopian regions

	Budget share food	*Price increase (%) Jan – July '08*
Addis Ababa	0.41	69.4
Afar	0.54	57.0
Amhara	0.62	54.4
Benishangul Gumuz	0.57	63.8
Dire Dawa	0.51	69.1
Gambela	0.55	49.6
Oromia	0.59	93.2
SNNP*	0.57	68.5
Somalia	0.61	74.4
Tigray	0.58	79.1
Ethiopia total	0.54	69.4

*Southern Nations, Nationalities and Peoples region. Source: own calculations from CSA (2008)

Using the information on price increase for the period January – July 2008 (second column of table 4), and supposing that for short periods of time, populations can spend their whole budget on food, we calculate the maximum daily ration of calories that can be purchased in July, 2008. If this daily ration is lower than the daily calorie intake of December 2007, we obtain a calorie gap.

Under these assumptions, only Addis Ababa, and the states of Afar, Benishangul Gumuz and Dire Dawa succeed in maintaining their pre-crisis consumption levels. In Gambela, the situation is the most dramatic, with average consumption falling almost 6.5 %, compared to an

[12] The countries are: Bolivia, Cambodia, Madagascar, Malawi, Nicaragua, Pakistan, Peru, Vietnam, and Zambia.

average decrease for Ethiopia of almost 2.5 %. For the whole of Ethiopia, the food gap equals almost 4000 billion Kcal, which is equivalent to 4.2 million Ethiopians on a full ration, the majority of which are concentrated in the Oromia and SNNP (Southern Nations, Nationalities and Peoples) regions. Indeed, these two regions are also named as the two concentration areas for relief food assistance by WFP (2008), next to the Somali region, which ranks fourth in terms of the consumption gap. With respect to its magnitude this number comes close to the WFP estimate of 6.4 million needing immediate food relief, with the qualification that our estimate only accounts for the adverse effects of higher food prices and does not include other important issues, such as the increased prices of fuel. Figure 8 shows the spatial pattern of the calorie gap in billions of Kcal within Ethiopia.

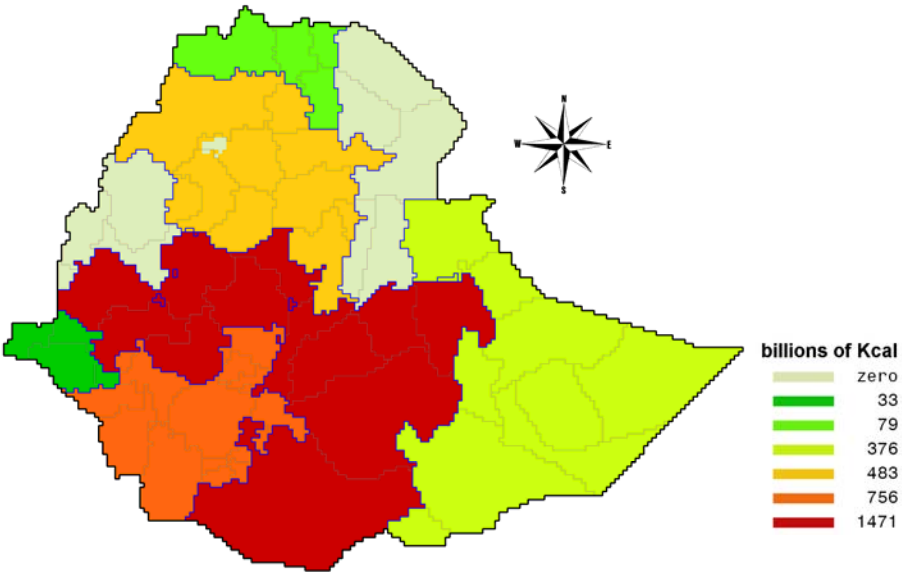

Figure 8: Ethiopia: Calorie gap in billions of Kcal per province. Source: own calculations.

6. Conclusion

As poverty and hunger are basic yardsticks of underdevelopment and destitution, the need for reliable statistics in this domain is self evident. However, while the measurement of poverty through surveys is relatively well documented in the literature and a reasonable degree of methodological consensus has been emerging, for undernutrition, information is much scarcer, particularly regarding adults, and very different methodologies are applied for children and adults. Whereas for children, a time series of observations on anthropometric indicators for many countries is available (Unicef/WHO), for the undernourished population as a whole, indicators are estimated in an indirect way. Remarkably, although FAO (2008) provided updates of total undernutrition for almost all countries in the world for the years 2003-2005, reports on progress made with respect to the Millennium Development Goals published since 2007 no longer mention this indicator, not even in their statistical appendices. Consequently, all progress made in terms of combating hunger is now monitored only on the basis of the indicator on children's weights.

Our paper shares the view that indirect estimates of the total number of people suffering from undernutrition have many flaws, including the lack of spatial detail, but at the same time we submit that this does not warrant neglecting the nutritional status of adults altogether. Hence, we use direct anthropometric data on women's' weights and BMI in DHS surveys - the same surveys that are used for the assessment of the children – to provide an estimate for undernutrition among adults in Sub-Saharan Africa, and assess its reliability.

Yet, however relevant in the monitoring process, we must acknowledge that even the best of indicators does not shed much light on the underlying causes of hunger and poverty, and the risks that threaten vulnerable populations. This requires further work, including the development of a more comprehensive database of the food economy, in which our anthropometrically-based calculation of calorie intake enter as important input, to be confronted with trade data, production estimates and recorded food aid deliveries, but also to be complemented with data on transport possibilities, climate characteristics and characteristics of the population such as the sources of income, the possibilities to cope with adverse conditions such as droughts, floods, locust plagues or animal diseases. Indeed, many of the relevant variables are also reported upon in the DHS surveys. These could provide the basis for more thorough analysis of the relations between nutritional, health, and socio-economic indicators within a consistent, spatially explicit database. With this it becomes possible to monitor trends over the medium term. In parallel, case study simulations for selected areas could be conducted, based on limited data sets, to provide fast updates, as illustrated in our small exercise on the impact on Ethiopia of the 2008 price hike.

Appendix A: data availability and inference rules

Table A.1. Weights of women and children, heights of women

Country	Source*	Year	Comment
Angola	WHO database	2001	Children
Angola	WFP (2005a)	2005	Adults
Benin	DHS	2006	
Botswana	WHO database	2000	Children
Burkina Faso	DHS	2003	
Burundi	DHS	2000	
Cameroon	DHS	2004	
Central African Republic	DHS	1994/1995	
Chad	DHS	2004	
Comoros	DHS	1996	
Côte d'Ivoire	DHS	1999	
Congo, rep.	DHS	2005	
Dem. Rep. Congo	DHS	2007	
Djibouti	MICS	2006	Children
Eq Guinea	WHO	2000	Children
Eritrea	DHS	2003	
Ethiopia	DHS	2005	
Gabon	DHS	2000	
Gambia	MICS	2005	Children
Ghana	DHS	2003	
Guinea	DHS	2005	
Guinea Bissau	MICS	2006	Children
Kenya	DHS	2003	
Lesotho	DHS	2004	
Liberia	WHO database	2000	Children
Madagascar	DHS	2003/2004	
Malawi	DHS	2004	
Mali	DHS	2006	
Mauretania	DHS	2000/2001	
Mauritius	WHO	1995	Children
Mozambique	DHS	2003	
Namibia	DHS	2000	
Niger	DHS	2006	
Nigeria	DHS	2003	
Rwanda	DHS	2005	
Sao Tome	WHO database	2007	Children
Senegal	DHS	2005	
Sierra Leone	MICS	2005	Children
Somalia	MICS	2006	Children
South Africa	WHO	1999	Children
South Africa	DHS	1998	Women and men
Sudan	WHO database	2000	Children
Swaziland	DHS	2006	Women and men
Tanzania	DHS	2005	
Togo	DHS	1998	
Uganda	DHS	2006	
Zambia	DHS	2001/2002	
Zimbabwe	DHS	2005	

* notes: DHS = Demographic and Health Surveys, USAID, MICS=Multi Indicator Cluster Surveys, UNICEF

Table A.2. Inference rules applied

Imputed country	*Imputed variable*	*Reference country*	*Remarks*
Botswana	Adult calorie intake	Namibia	Corrected for child calorie intake
Burundi	Adult calorie intake	Ethiopia	Corrected for child calorie intake
Eq. Guinea	Adult calorie intake	Namibia	Corrected for child calorie intake
Djibouti	Adult calorie intake	Kenya	Corrected for child calorie intake
The Gambia	Adult calorie intake	Senegal	Corrected for child calorie intake
Liberia	Adult calorie intake	Burkina Faso	Liberian child calorie intake used to create spreading of consumption
Mauritius	Adult calorie intake	Gabon	Corrected for child calorie intake
Guinea Bissau	Adult calorie intake	Niger	Corrected for child calorie intake
Sao Tome	Adult calorie intake	South Africa	Corrected for child calorie intake
Sierra Leone	Adult calorie intake	Niger	Sierra Leonean child calorie intake used to create spreading of consumption
Somalia	Adult calorie intake	Ethiopia	Corrected for child calorie intake
Sudan	Adult calorie intake	Ethiopia	Corrected for child calorie intake, adjustment for Darfur
Cape Verde	Adult and child calorie intake	Gabon	
Reunion	Adult and child calories intake	Gabon	
St Helena	Adult and child calorie intake	Gabon	
Seychelles	Adult and child calorie intake	Gabon	

Appendix B Comparison of nutrition surveys

Table B.1. Comparison of nutrition surveys for Asian countries

Country	Years of surveys	Children with height-for-age <-2sd	Sample-size	Source
Bangladesh	1995-96	51.4	2614	Non-DHS
	1996-97	54.6	4787	DHS
Bangladesh	1999-2000	44.6	5421	DHS
	2001	48.5	71931	Non-DHS
India (rural)	1996-97	42.6	22959	Non-DHS
	1998-99	51.6	24396	DHS
Indonesia (WFA)*	2000	24.6	70602	Non-DHS
	2001	26.1	11693	Non-DHS
Korea (DPR)	2000	45.2	4175	MICS
	2002	38.6	5232	Non DHS
Maldives	1994	29.6	1994	Non DHS
	1995	26.9	798	MICS
Mongolia	1999	24.6	4037	Non DHS
	2000	24.6	5784	MICS
Myanmar*	1997	47.8	4894	Non DHS
	2000	34.2	8081	MICS
	2003	32.2	5390	MICS
Nepal	1996	48.4	3705	DHS
	1996	53.1	5525	MICS
	1997/98	54.2	17241	Non DHS
	2001	50.5	6409	DHS
Pakistan	1990-91	49.6	4056	DHS
	1990-94	36.3	3141	Non DHS
Sri Lanka	1993	23.8	3067	(semi)DHS
	1995	20.4	2782	Non DHS
Sri Lanka	2000	13.5	2531	(semi) DHS
	2001	13.9	1716	Non DHS
Thailand	1993	16.0	11748	Non DHS
	1995	13.4	4178	Non DHS
Vietnam	1998	35.9	12919	Non DHS
	1999	38.7	93469	Non DHS
	2000	36.5	94469	Non DHS
Yemen	1996	44.6	3833	MICS
	1997	51.7	7501	DHS

*: Corrections made to extrapolate undernutrition in children <3 years to children <5 years, by multiplying percentage children with low height-for-age with factor 1.15; Sources: DHS, WHO

Table B.2. Comparison of nutrition surveys for African countries

Country	Years of surveys	Children with height-for-age <-2sd	Sample size	Survey type/ organisation
CAR*	1994/95	38.6	2310	DHS
	1995	28.4	2225	Non DHS
Chad	1996/97	40.1	5665	DHS
	2000	28.1	5043	Non DHS
Egypt	1997-98	24.9	3328	DHS
	1998	20.6	3997	DHS
	2000	18.7	10193	DHS
Ghana	1987-88	24.6	1492	Non DHS
	1988	27.6	2011	DHS
	2003	29.9	3183	DHS
	2006	22.4	3166	MICS
Guinea	1999	29.9	2452	DHS
	2000	40.9	1457	Non DHS
Kenya	1998	33.0	4413	DHS
	2000	35.3	5917	MICS
	2003	30.3	5306	DHS
Madagascar*	1995	49.8	5049	MICS
	1997	53.1	3080	DHS
Malawi	1997-98	59.1	6309	Non-DHS
	2000	49.0	9322	DHS
	2004	47.8	8520	DHS
	2006	45.9	20747	MICS
Mali*	1995-96	34.6	4678	DHS
	1996	48.6	n.a.	MICS
Niger*	1998	47.3	4022	DHS
	2000	39.7	4616	MICS
Nigeria	2001	42.0	4954	Non DHS
	2003	38.3	4789	DHS
Rwanda (rural)	1991-92	52.2	1939	Non DHS
	1992	49.4	4177	DHS
Senegal	1992-93	24.7	3865	DHS
	1996	22.9	n.a.	MICS
Tanzania	1996	43.4	5344	DHS
	1999	43.8	2821	DHS
Zambia	1996/97 (national)	42.4	5443	DHS
	1999 (national	53.0	1095000	MICS
	2001 (national	46.8	5784	DHS

*: Corrections made to extrapolate undernutrition in children <3 years to children <5 years, by multiplying percentage children with low height-for-age with factor 1.15; Sources: DHS, WHO

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The Centre for World Food Studies (Dutch acronym SOW-VU) is a research institute related to the Department of Economics and Econometrics of the Vrije Universiteit Amsterdam. It was established in 1977 and engages in quantitative analyses to support national and international policy formulation in the areas of food, agriculture and development cooperation.

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