What we eat:
Changing patterns of food consumption
around the world

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Lima, Peru, 23 September 2014
ABSTRACT

This paper explores changes in the level and composition of per capita food consumption across the world; it does not discuss intra-country inequalities in food access, nor the prevalence of hunger resulting from those inequalities.

The trebling of the world's food output since 1961 whilst population only doubled caused a marked increase in per capita food supply. By 2011 the average human was consuming nearly 2900 daily kilocalories per person, up from less than 2200 in 1961; per capita protein intake had also increased significantly from 61 to 80 grams per day. Besides these overall increases in food consumption, the composition of the average diet also changed.

Consumption of cereals reached a plateau or slightly declined in per capita terms, whilst consumption of other foods increased significantly. All the increase in dietary energy supply since 1990 reflects higher consumption of non-cereal food; per capita cereal food consumption stabilised or declined. The saturation level at which cereal food consumption stabilises seems to vary across regions, probably due to local culture and custom.

Greater food consumption is not always a good thing: some regions of the world have enormously increased their consumption of fats, especially in the form of vegetable oil, contributing to a growing obesity epidemic. But humans have also improved their diets in some more beneficial ways, consuming more pulses, fruit, vegetables, meat, fish, milk and eggs. These trends are present in all major regions, albeit with variation across regions.

There are no detailed data on the micronutrient (vitamins and minerals) content of food consumption, but the tendency to a more diversified diet, with increased presence of fruits, vegetables and foods of animal origin indicates that the micronutrient content of food consumption is, on average, increasing.
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Introduction
During the half century 1961-2011 the world's population increased by a factor of 2.2, passing from 3.1 to 6.9 billion people, but primary food output increased by a factor of 3.3 (Maletta 2014b) and interna
tional trade in food commodities expanded by a factor of 8.5 (Maletta 2014c). This greater availability of food for a growing population translated into an increase in per capita food consumption, however measured, and involved also changes in the composition of food consumption.

This larger output, more widely distributed by trade, was an important factor for progress in the world's food security. Yet food security is not limited to ensuring that sufficient food is available, but depends on the capacity of individuals to access food according to their needs and preferences (WFS 1996, 2009; Maletta 2014a), and assessing this would require examining the distribution of food amongst households and individuals. However, a large part of the overall inequality in food access depends on differences in per capita availability across nations. For this reason, this paper is focused on trends in per capita food consumption, first in terms of dietary energy and then in terms of specific food items and nutrients; one major goal is to elicit major changes in average dietary composition at world level and in various world regions. Discussion of food access would necessitate a different paper to be properly discussed; this paper is only concerned with per capita consumption.

In this context, food consumption usually refers to net food supplies delivered for consumption, usually estimated as a residual in national food balances (see the Technical Appendix for details). This approach takes the domestic supply of each food item (domestic production, plus imports, minus exports, minus change in stocks), and deducts non-food uses (seed, animal feed, waste, and non-food industries); the residual is an estimate of amounts delivered for human food consumption, or apparent consumption.

We review apparent food consumption trends for macronutrients, chiefly dietary energy and protein, since consumption of micronutrients (vitamins and minerals) is not regularly monitored; we discuss sources of dietary energy (carbohydrates, protein, fat, and alcohol), and consumption of specific foods (cereals, sugar, tubers, fruits, vegetables, vegetable oil, meat, eggs, and dairy products). Some of these are important indicators of dietary diversity and proxies for micronutrient consumption.

Dietary energy
One major purpose of food is to provide fuel for the body to produce energy. Our cells can produce energy by burning a simple sugar (glucose); the latter is manufactured in the body on the basis of some substances found in food (carbohydrates, protein, fat, or alcohol). The amount of dietary energy the body can get from whatever foodstuff we eat is a crucial aspect of food consumption.

Dietary energy supply
The world daily average dietary energy supply (or apparent consumption) per person has steadily increased from less than 2200 kilocalories in 1961 to nearly 2900 in 2011, as shown in Figure 1. By 1961 the world survived on a per capita amount of energy barely above normal requirements for the average person, which are about 2100 kcal/person/day (hereafter abbreviated as kcpd). Inequality between and within countries implies that at that time a large number of people (probably half or more) inevitably

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1 These needs (see FAO 2004 for details) cover energy expenditures necessary on average for people to maintain their body weight at the midpoint of the acceptable range of weights for their height and age-sex group, whilst leading (on average) a moderately active lifestyle; it also implies normal growth for children, and provisions for pregnancy and lactation. People can stay healthy with somewhat less or more than this normal energy expenditure, keeping their weight within a range of acceptable weights for their height, and performing various levels of physical activity (from light or sedentary to very active).
consumed less than their normal needs.\(^2\) By 2011, this had profoundly changed, after fifty years of unabated growth in food production and food energy consumption. The average supply of dietary energy had increased by one third, to nearly 2900 kilocalories per day, well above average requirements.

![Figure 1. World per capita dietary energy supply (kilocalories/person/day), 1961-2011. Source: FAOSTAT.](image)

With a world population in 2011 that is more than twice as large as in 1961, just maintaining the 1961 level of dietary energy would have implied a significant growth in food availability (multiplying global output by a factor of 2.3, or about 1.68% per year). Attaining by 2011 a significantly higher per capita amount of dietary energy than existed in 1961 implied, of course, a yet higher rate of cumulative agricultural growth during half a century (namely 2.51% per year). However difficult such a feat may have seemed back in the 1960s, the fact is that the world has strongly increased per capita dietary energy supply in the past half century.

The dismal situation of the early 1960s was vastly different by 2011: the world average is estimated to have reached 2868 kcpd; even allowing for unequal distribution, this leads to far fewer people consuming less than their needs (though others consume far more than required — or advisable). Figures on distribution and access to food do confirm this idea, but the point will be discussed later: this section is mostly restricted to per capita supplies as such, not discussing inequality of access across households and individuals, a matter sufficiently complex as to deserve a separate treatment.

Per capita apparent consumption of dietary energy is, of course, much higher in rich countries than in poor ones (Figure 2). Asia and Africa are below the world average, albeit gradually approaching it; LAC is slightly above the world mean, whilst Europe and Northern America are clearly much above. As of 2011, per capita apparent consumption in Africa was 2615 kcal/person/day (kcpd), compared to 3617 in Northern America (US and Canada). However, per capita consumption in Africa in 2011 was far above its 1961 level (only 1990 kcpd); it was indeed similar to the world average of 1987-88 and roughly equivalent to the levels attained by Latin American about 1980 and by Asia in the mid-2000s. Thus Africa seems to be advancing on the steps of other developing regions with a lag of 1-3 decades. This is further indication of progress along the latest half century, even in regions that lag behind. Progress, of course, should desirably be faster, but this is the way it has been occurring.

Dietary energy supply (or apparent consumption), thus, has increased in all continental regions. At the bottom, Africa passed from around 2000 kcpd in the early 1960s and 1970s to more than 2600 in 2011.

\(^2\) Part of them were probably undernourished in the sense of consuming less than the minimum acceptable amount, thus endangering health and survival, but this matter is not addressed in this paper.
Asia (or more properly, Asia-Pacific), which was at the bottom with some 1800 kcpd in the early 1960s, overtook Africa around 1980, and by 2011 was at 2762 kcpd, approaching the world average. Since Asia overtook Africa in the early 1980s, both have been increasing their calories at a similar rate, with Africa keeping itself about 150-200 kcal below Asia, i.e. lagging Asia by about one decade; in this regard, Africa was in 1991 approximately where Asia had been ten years earlier, and the same was true in 2001 and 2011. Latin America and the Caribbean (LAC), on the other hand, progressed in lockstep with the world average from about 2250 to nearly 3000 daily kilocalories per capita.

People in the richer parts of the world consumed already around 3000 kcal per day in 1961, and have significantly moved up since that period: Northern America overtook Europe in the mid-1980s, and after 2000 it was (at nearly 3700 kcpd) in the midst of a severe obesity epidemic. It is, however, encouraging that the figure for Northern America appears to have peaked by 2002-2004 and has slightly declined afterwards. Europe as a whole was approaching 3400 kcpd in the late 1980s, but suffered a significant setback after 1990 linked to the collapse of the Soviet bloc, causing a fall of some 500 kcpd in Eastern Europe and 200 kcpd for the all-Europe average; a slow recovery started by the mid-1990s. By 2011 Europe was back at pre-1990 levels (3314 kcpd for the entire region). The decline experienced in the formerly central-planning bloc of Eastern European countries was never suffered by people in the rest of Europe: this sub-region's supply of dietary energy has been about 3400-3500 kcpd since the mid-1980s and above 3500 kcpd in 2011.

As the precedent paragraph suggests, there is considerable variation within continental regions, as exemplified by the gap between Eastern Europe and the rest of Europe. Within Asia there are also great variations, with rich countries like Japan on one extreme and poor ones like Afghanistan or Bangladesh in the other. Even among the two bigger countries, China progressed more than India during recent decades, in which both countries reformed their economic systems and got strong economic growth. Per capita consumption in some Latin American countries like Mexico or Argentina are at the developed-country level of over 3000 kcpd while others (Bolivia, Haiti, and some Central American countries) are still around 2000-2200 kcpd. There is also significant sub-national variation (e.g. between poorer Northern and richer Southern Brazil). In Africa there is a considerable gap between the better-fed North and the Sub-Saha-
ran region. Throughout this paper these intra-regional or sub-national differences go mostly unmentioned for the sake of brevity, but their existence should be remembered.

**Sources of dietary energy**

The general increase in dietary energy supply was accompanied by changes in the chemical sources of that energy. Most human body cells generate energy, and they do it by burning glucose, a simple sugar; the body can extract or manufacture glucose from some carbohydrates (sugars and starch) and also from protein, fat and alcohol. As shown in Table 1, total energy supply grew since 1961 to 2011 by 674 kcpd or 31%, but the main contribution for that rise came from increased consumption of fat (which increased by 74%, from 428 to 744 kcal).

The percentage increase in carbohydrates was much lower (18%); that of protein (31%) and alcohol (30%) was instead proportionate to the general increase of dietary energy. About two thirds of carbohydrates come from cereals (929 kcpd in 1961; 1124 in 1986; and 1115 in 2011); the contribution from cereals increased in 1961-86 but then stagnated or slightly decreased in 1985-2011. The share of carbohydrates in total dietary energy decreased from 67% in 1961 to 60% in 2011, whilst the share of fat went up, from 19.5% to 26.0%. Fats supplied by 2011 a fourth of total energy, but contributed nearly a half of the increase in calories since 1961 (adding 317 kcpd or 47% of the total increase of 674 kcpd).

Table 1. Chemical sources of dietary energy, worldwide, 1961-2011 (FAOSTAT food balance sheets)

<table>
<thead>
<tr>
<th></th>
<th>kcal/person/day</th>
<th>Percentage composition</th>
<th>Change in kcal</th>
<th>Percent change</th>
<th>% of total change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>2194</td>
<td>2590</td>
<td>2868</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td>Carbohydrates a</td>
<td>1468</td>
<td>1663</td>
<td>1734</td>
<td>66.9%</td>
<td>64.2%</td>
</tr>
<tr>
<td>From cereals, excl. beer</td>
<td>929</td>
<td>1124</td>
<td>1115</td>
<td>42.3%</td>
<td>43.4%</td>
</tr>
<tr>
<td>From starchy roots</td>
<td>161</td>
<td>118</td>
<td>129</td>
<td>7.3%</td>
<td>4.5%</td>
</tr>
<tr>
<td>From sugar and sweeteners b</td>
<td>192</td>
<td>237</td>
<td>229</td>
<td>8.7%</td>
<td>9.1%</td>
</tr>
<tr>
<td>From other foods c</td>
<td>186</td>
<td>184</td>
<td>260</td>
<td>8.5%</td>
<td>7.1%</td>
</tr>
<tr>
<td>Protein</td>
<td>246</td>
<td>280</td>
<td>321</td>
<td>11.2%</td>
<td>10.8%</td>
</tr>
<tr>
<td>Fat</td>
<td>428</td>
<td>581</td>
<td>744</td>
<td>19.5%</td>
<td>22.4%</td>
</tr>
<tr>
<td>Alcohol d</td>
<td>53</td>
<td>67</td>
<td>69</td>
<td>2.4%</td>
<td>2.6%</td>
</tr>
</tbody>
</table>

(a) Energy from carbohydrates (total, and also for cereals and starchy roots): obtained by difference (total calories from each food group, minus the calorie equivalent of their fat and protein content, minus alcohol).

(b) Total energy supply from sugar crops, honey, and other natural sweeteners.

(c) Carbohydrates in pulses, fruit, vegetables, nuts, and other foods. Obtained by difference (total carbohydrates minus carbohydrates in cereals, starchy roots, and sugar).

(d) Total calories from alcoholic beverages. Includes a very small amount of energy (less than 1 kcal/person/day) from residual carbohydrates and protein found in some fermented alcoholic beverages (e.g. beer). Protein and fat: grams/person/day converted into energy at 4 and 9 kcal/gram respectively.

Some totals may not exactly add up due to rounding.

**Share of fat in dietary energy**

At world level the share of fats in total dietary energy has increased from 19.5% in 1961 to 26% in 2011. An increasing per capita supply of dietary energy with an ever growing share of fat and a decreasing share of carbohydrates are all major trends in world food consumption during recent decades. Increased consumption of fat represents 47% of the total increase in dietary energy supply. The average human had a daily fat supply of 47.5 grams in 1961, providing 428 kcal; this increased to 82.3 grams by 2011, supplying 744 kcal. All we shall see later, most of this increase comes from fats of vegetal, rather than animal, origin, and chiefly in the form of vegetable oil.

Fat is a necessary food element, not only as a store of potential energy but also for other purposes. But fat should not be consumed or bodily stored in excess; people consuming more than the required amount...
of fat are bound to accumulate excess fat in their bodies and ultimately become overweight or obese, entailing various health risks. Although the required amount of fat may vary across individuals by sex, age group, body shape, ethnic group, or other reasons, it is generally recognised that at least 15% of dietary energy intake should be in the form of fat, and that a diet providing more than 30% of energy in the form of fat may be in dangerous territory. Unfortunately, large sections of the human population are exceeding this upper limit. As shown in Figure 3, North America and Europe are well above; by 2011 Europeans were consuming on average 34% of their dietary energy in the form of fat, and North Americans about 40%, and both percentages were (albeit slowly) still growing. Latin America and Asia are also increasing the fat percentage of their dietary energy. The only exception is Africa, which keeps since the 1960s a nearly stable share of about 20%, coinciding with the average world level of half a century back.

![Figure 3. Percent contribution of fats to total dietary energy, by region (1961-2011). FAOSTAT.](image)

These regional changes in the amount of dietary energy (Figure 2) and in the percentage of fat energy (Figure 3) involved changes in the average diet: quantities consumed of various foods have generally increased, but at different rates; the diet composition has changed. The next section briefly reviews the main changes in the composition of food consumption.

**A changing diet**

*Overview of diet changes worldwide*

There were significant changes since 1961 in the composition of food consumption, as shown at Table 2. The first finding is that whereas total dietary energy increased, the consumption of staple foods has tended to stall, most notably in the more recent decades of this past half century. Thus consumption of cereals moderately increased at the world level from 1961 to 1986, but it slightly decreased in more recent years; per capita consumption of tubers is lately below its 1961 levels, whilst 'empty calories' from vegetable oil are clearly up (from 4.6 to 11.6 kilograms per person/year (kg/pyr), an increase of 148%).

Such large increase in vegetable oil may have negative implications, but other changes are more conducive to good health. Large increases occurred in the consumption of fruit, vegetables, and foods of animal origin. Per capita consumption of fruit and vegetables has doubled, as nearly did meat and eggs; in particular, pork and fish doubled and poultry meat increased fivefold (from 2.8 to 14.2 kg/pyr), whilst meat of cattle, sheep, goat and other animals remained stable.

The stability of per capita beef consumption is particularly interesting, since a widespread belief is that it is increasing. Total beef consumption is indeed increasing, due to population growth, but it is not increa-
singing in *per capita* terms. The fastest-growing item in per capita terms is poultry (+399% since 1961), chiefly chicken, followed by vegetable oil (+148%) and by fruit, vegetables, pork, fish/seaweed and eggs (all around +100%). Sugar and other natural sweeteners have increased by a mere 21%, mostly before 1986, and calories from alcohol have also grown in a moderate proportion (30% in 50 years).

| Table 2. World per capita consumption of various foods, 1961-1986-2011 (FAOSTAT) |
|-------------------------------------------------|-----------------|-----------------|-----------------|
| Cereals (exc. beer)            | 127.0     | 148.1     | 144.9     | 14%        | 4.6       | 8.6       | 11.5      | 148%        |
| Maize                          | 11.0      | 14.2      | 17.5      | 58%        | 37.3      | 48.9      | 72.9      | 95%         |
| Rice (milled equiv.)           | 37.6      | 51.8      | 53.1      | 41%        | 63.2      | 75.7      | 133.6     | 111%        |
| Wheat                          | 54.5      | 68.6      | 64.4      | 18%        | 22.9      | 31.5      | 41.5      | 82%         |
| Other cereals                  | 23.9      | 13.5      | 9.9       | -58%       | 9.3       | 10.5      | 9.2       | -1%         |
| Starchy roots (tubers)         | 76.1      | 55.9      | 62.6      | -18%       | 7.9       | 12.0      | 15.2      | 92%         |
| Potatoes                       | 35.1      | 26.8      | 34.3      | -2%        | 2.8       | 6.6       | 14.2      | 399%        |
| Sweet potatoes                 | 25.9      | 14.2      | 7.8       | -70%       | 1.9       | 1.6       | 1.9       | -1%         |
| Cassava                        | 12.1      | 12.1      | 14.4      | 19%        | 0.9       | 0.7       | 1.0       | 11%         |
| Other tubers                   | 3.0       | 2.8       | 6.0       | 104%       | 1.5       | 1.8       | 2.2       | 43%         |
| Sugar & sweeteners             | 19.5      | 24.2      | 23.7      | 21%        | 8.9       | 12.8      | 18.6      | 108%        |
| Pulses                         | 9.3       | 6.3       | 6.7       | -28%       | 4.5       | 6.1       | 8.8       | 95%         |
| Alcohol*                       | 7.6       | 9.6       | 9.9       | 30%        | 77.1      | 80.5      | 90.6      | 17%         |

(*) Amount of alcohol in alcoholic beverages (fermented or distilled); it may correspond to various amounts of liquid beverage depending on alcoholic content. Based on kcal from alcoholic beverages in FAOSTAT food balances, converted into alcohol at 7 kcal per gram of alcohol, ignoring trace amounts of carbohydrates and protein found in some fermented alcoholic beverages. Cereals include rice in milled-equivalent terms, and exclude the amounts of cereal used for making beer. Sugar and sweeteners include honey and other natural sweeteners. 'Milk (whole equivalent)' is the sum of three FAOSTAT items: 'Milk excluding butter', 'Butter and ghee', and 'Cream'. Source: FAOSTAT.

### Regional diet variation

Per capita consumption of various foods, and its changes over time, varies considerably across regions (and even more across individual countries). Table 3 provides a summary for major foods and food groups at the endpoints of the half century (1961 and 2011) and at a midpoint year (1986).

Many peculiarities and changes may be pointed out across the various regions and food groups. One of the most important is the fact that cereal food consumption tends to grow less than other foods, and becomes a less significant source of dietary energy in more developed regions. Another major trend is the rise in consumption of vegetable oils, and also in food products of animal origin (meats, eggs, milk).

Consumption of fruit and vegetables also expanded; the world level in 2011 was equivalent to a daily supply of 202 grams of fruit and 183 grams of vegetables for the world's average person. Some of these changes over time, and variation across regions, are briefly discussed below.

| Table 3. Per capita consumption of major food groups by region, 1961-2009 (kg/person/year) |
|-----------------------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                                | World | Northern America | Europe | World | Northern America | Europe | World | Northern America | Europe |
| Cereals                        | 127  | 148.1 | 144.9 | 86.8 | 95.4 | 105.3 | 167.4 | 140.9 | 135.0 |
| Pulses                         | 9.3  | 6.3 | 6.7 | 3.7 | 3.4 | 4.0 | 3.5 | 2.7 | 2.5 |
| Tubers                         | 76.1 | 55.9 | 62.6 | 55.9 | 60.5 | 62.0 | 115.2 | 93.1 | 82.5 |
| Sugar & sweeteners             | 19.5 | 24.2 | 23.7 | 51.5 | 57.8 | 59.4 | 32.5 | 41.4 | 39.1 |
| Vegetable oils                 | 4.6  | 8.6 | 11.5 | 11.5 | 22.7 | 30.2 | 7.9 | 13.4 | 17.1 |
| Fruits                         | 37.3 | 48.9 | 72.9 | 78.4 | 120.4 | 100.3 | 49.4 | 72.7 | 87.6 |
| Vegetables                     | 63.2 | 75.7 | 133.6 | 92.4 | 108.2 | 113.2 | 85.4 | 109.0 | 126.8 |
| Meat & offals                  | 24.4 | 33.3 | 43.7 | 92.4 | 108.2 | 113.2 | 85.4 | 109.0 | 126.8 |
| Fish & seafood                 | 8.9  | 12.8 | 18.6 | 13.2 | 19.0 | 21.7 | 13.9 | 22.5 | 19.9 |
| Eggs                           | 4.5  | 6.1 | 8.8 | 17.4 | 14.1 | 13.7 | 9.0 | 14.1 | 12.2 |
| Milk, whole                    | 77.1 | 80.5 | 90.6 | 269.1 | 255.0 | 255.9 | 177.5 | 224.2 | 219.8 |
Fed up with cereals

Cereals are the basic foodstuff of mankind since the invention of agriculture in the Neolithic. In poor countries cereals often provide more than one half of dietary energy. As per capita income grows, however, diets diversify and per capita cereal food consumption tends to stall and eventually decline. At any given time, some (typically poorer) countries may be still increasing their per capita food consumption of cereals whilst other countries are already in the declining phase. The balance of the two sets of countries resulted in an increase in world per capita food consumption of cereals until the mid-1980s, after which it largely stabilised. World per capita cereal food consumption has not increased in the latest three decades: it moderately increased from about 128 kilograms/person/year (kgpyr) in 1961 to around 150 in 1984, where it stayed until 1999; then it slightly decreased in 2000-2002, and was about 147 kgpyr from 2002 to 2011 (Figure 4).

Thus in spite of ever growing cereal output (Maletta 2014b) and increasing consumption of dietary energy (Figure 1), per capita cereal food consumption appears to have reached a plateau or saturation level, at least at the world level.

This overall picture is generally similar in all major regions though with significant differences in the timing of cereal consumption saturation (Figure 5), in relation to each region’s history and level of development. Europe and North America have in fact been experiencing a decline in cereal food consumption. Europe was declining since 1961 up to the early 1990s, when it stabilised around 135/140 kgpyr. North America, instead, increased cereal food consumption per head up to the early 1990s, and only then started a decline. A similar course was followed by Asia, where per capita consumption of cereal food...
increased from 1961 to 1981, and then declined in a gradual manner up to 2011. Latin America, like Asia, increased per capita cereal food consumption until the early 1980s, and then stabilised. Africa per capita cereal consumption increased until the mid-1990s but has stalled since: it passed from 126 kgpyr in 1961 to 149 in 1996 and grew only marginally to 150 kgpyr in 2009-2011.

Food consumption of cereals is not directly correlated to levels of income, economic development, or per capita supply of dietary energy. Africa (the poorest region in terms of income, dietary energy and other socioeconomic indicators) has been lately consuming more cereal per capita than Europe, despite the great disparity between their dietary energy supplies or between their levels of economic development. On the other extreme, North America (the region with the highest level of dietary energy supply) kept throughout the past half century the lowest level of per capita cereal food consumption among these world regions. These facts clearly reveal, perhaps surprisingly, that a high level of cereal food consumption is not per se an indicator of living standards or overall food security, nor can be used as a good proxy for total dietary energy supply.

Figure 5. Apparent food consumption of cereals, by region, 1961-2011 (kg/year per capita). Source: FAOSTAT.

Some cereal is used for non-food scopes (e.g. fodder or biofuels), and these non-food uses are widely regarded as increasing; it is thus perhaps surprising that the share of cereal output that is devoted to food has no long-term tendency to increase or decrease: it was about 49% in the early 1960s; it decreased to 42% in the mid-1970s, then gradually returned to levels around 48-50% in the 1980s and 1990s, and fell again to about 42% in the late 2000s. Even if the use of coarse grains (chiefly maize) as animal feed or as feedstock for biofuels has increased, the use of other cereals (like barley or millet) for non-food purposes (chiefly fodder) has tended to decline. Thus the stagnation or decline of cereal food consumption cannot be attributed to an increasing use of cereals for other purposes. It is entirely due to consumer preference for other foods to complement or replace cereals. These preferences bear some relation to economic development (hence the timing of cereal food saturation) but also vary with local culture and custom, causing persistent differences between regions of similar degree of development such as Europe and North America.

The rise in total dietary energy supply in the two more recent decades came almost exclusively from non-cereal food (Figure 6). From 1961 up to 1993 the contributions of cereal and non-cereal dietary en-
ergy were almost the same, and progressed at an equal pace; from the early 1990s onwards, cereal food energy stagnated and slightly declined, whilst dietary energy from other foods continued rising in an accelerated manner. **Progress in world per capita dietary energy supply since 1990 is entirely attributable to non-cereal food.**

Change in dietary energy consumption, therefore, cannot be inferred from changes in the amount of dietary energy supplied by cereals. The latter has been stagnant for three decades, whilst the former is rapidly increasing, especially since the early 1990s.

This pattern occurs also at major regions, albeit varying with the regional level and growth of cereal consumption and total energy supply. In Asia and Africa cereals provide more energy than other foods (although the latter overcame the former in Africa after the turn of the century). The opposite happens in Latin America, Europe and North America: cereal calories provide less than one half of the total. In all cases per capita dietary energy from cereals has grown more slowly than other sources of dietary energy, and in some cases declined, as shown in the following set of charts.

![Figure 6. World dietary energy supply from cereals (excluding beer) and from other foods, 1961-2009, in kcal/person/day](image)

**Cereal and non-cereal dietary energy by region, 1961-2011 (FAOSTAT)**

<table>
<thead>
<tr>
<th>World</th>
<th>Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Graph" /></td>
<td><img src="image" alt="Graph" /></td>
</tr>
</tbody>
</table>
In the case of Europe (which throughout this paper includes also the Asian parts of the former USSR), the collapse of the Eastern bloc caused a steep reduction in non-cereal and total dietary energy that is clearly perceptible after 1990, from which that region has gradually recovered since, but cereals did not decline in the wake of the bloc’s meltdown. The dip in Europe's dietary energy supply is concentrated in non-cereal food, and it entirely belongs in Eastern Europe. In the rest of Europe, instead, cereal energy was relatively stable in the 900-950 kcpd range; energy from other foods rose from 2000 to 2500 kcpd in 1961-1985, and remained stable afterwards. In Eastern Europe cereal food consumption has been steadily declining, before and after the transition of 1990-92, gradually converging with the rest of that continent. The contrast between Eastern Europe and the rest of Europe is shown in the following charts.

Cereal and non-cereal dietary energy, Eastern Europe and the rest of Europe, 1961-2011 (FAOSTAT)
In all regions the relative share of cereals in total dietary energy has shown a declining tendency in recent decades (Figure 7). In Asia and Africa the decline started about 1990, in Latin America around 1980; the European share has been falling since 1961, from 40% to 31%, whilst in North America the share of cereals had declined much before and is probably at a minimum: it hovered within a narrow range (about 20-24%) all along the past half century.

**Figure 7.** Share of cereals (excluding beer) in total dietary energy, by region, 1961-2011. Source: FAOSTAT.

The behaviour of Europe in this respect is also better understood if Eastern Europe is distinguished from the rest of that region (Figure 8): the temporary rise in the share of cereals in the early 1990s occurred solely in the Eastern part, as its population reduced consumption of non-cereal items as a result of the collapse of centrally planned economies. In the rest of Europe the share of cereals in total dietary energy did not show any such discontinuity; after its slight decline in 1961-1990, the share of cereals in the rest of Europe was quite stable in recent years, as it was in North America.

**Figure 8.** Share of cereals (excluding beer) in total dietary energy, in Eastern Europe and the rest of Europe, 1961-2011. Source: FAOSTAT. Eastern Europe includes the whole territory of the former USSR (even the Asian parts) and the various Asian countries formed upon the USSR dissolution.

**Animal and vegetal food**

One major trend in the past quarter century has been an increase in the share of dietary energy obtained from food of animal origin. At world level (Figure 9) this share hovered about 15.5% from 1961 up to the 1980s, but has been steadily increasing ever since, reaching 17.7% by 2010-2011. The change in the
share is not actually large (just about two percentage points), but it is evident that a new trend in this regard has affirmed itself during recent decades, signifying an important shift in diet composition.

The worldwide increase in the share of animal-origin calories, however, is mostly explained by Asia (and to a lesser extent Latin America), as shown in Figure 10. Asia and LAC are the areas that tended to increase their share of dietary energy of animal origin, from 6% to 16% in Asia and from 16% to 21% in LAC, whilst in Africa it remained essentially unchanged at about 7-8%. The more developed regions actually tended to reduce their relative reliance on animal-origin food: the share of animal-origin energy has declined steadily since 1961 in Northern America, from 35% to 27%; Europe's share rose from 25% in 1961 to 30% in 1989-90, and then joined the declining trend of Northern America to 27% in 2011.

The share of energy of animal origin is thus higher in rich countries, but tends to decline over time as those countries become more affluent, whilst it tends to rise as developing countries increase their standards of living. Overall, the animal origin share seems to follow an inverted U curve when analysed in terms of levels of economic development, being very low at low levels of income, rising with income until peaking at some intermediate (though relatively high) development level, and finally declining as countries become more affluent. In the case of Europe the recent decline has been compounded by the
sharp drop of non-staple food supply in Eastern Europe following the collapse of the central-planning economies around 1990, which have since rebounded tending to recover the levels attained before 1990. On the other hand, the behaviour of the percentage share of energy coming from food of animal origin is not to be confused with the absolute trend of animal-origin energy. Since total dietary energy has been generally on the rise, dietary energy of animal origin (at the world scale) has also tended to rise: it contributed 338 kcal/person/day in 1961, rising to 507 in 2011 (an increase of 50%).

**Animal and vegetal fats**

A rising consumption of foods of animal origin is often associated with a rise in the consumption of fats of animal origin. This is indeed so: per capita consumption of fats of animal origin has indeed increased in absolute terms. But consumption of animal-based fats has increased less than consumption of vegetable-origin fats (chiefly vegetable oil), as shown in Figure 11. As a rather intriguing consequence, the share of animal fat (relative to total fat consumption) has been decreasing (Figure 12), despite a rising share of foods of animal origin in total dietary energy supply.

![Figure 11. World per capita consumption of vegetal and animal fats, 1961-2011 (grams/person/day). Source: FAOSTAT.](image1)

![Figure 12. Share of fats of animal origin in world total consumption of fats, 1961-2011. Source: FAOSTAT.](image2)

Data by regions (not shown) indicate that the only region with an increase in the share of animal fat in total fat consumption is Asia, where it has risen from about 30% to about 45%. In all other regions (and at world level) the tendency is the opposite; even the huge size of Asia is unable to reverse this worldwide tendency, where the share of animal lipids clearly declines, mainly because of widespread and increasing consumption of vegetable oil.
**A flood of vegetable oil**

Per capita consumption of vegetable oil has greatly increased between 1961 and 2011, from 4.7 to 11.7 kgpyr. It is highest in North America, where consumption passed from 11.5 to 30.2 kgpyr in that period, well above the nearest competitor (Europe, which grew from 8 to 18). Consumption also grew rapidly in developing regions: Latin America (5 to 13 kgpyr), Asia (2.5 to 9.3), and Africa (5 to 9).

![Graph showing consumption of vegetable oil by region, 1961-2011 (kg/person/year). FAOSTAT.](image)

Increased consumption of vegetable oils is matched by rapid worldwide growth of oil-bearing crops such as soya, sunflower, oil palm, and others. As we have seen before, fats of vegetal origin (chiefly vegetable oil) have largely replaced animal fats (especially lard), albeit on the whole animal fats also increased, albeit to a lesser degree, chiefly led by increasing consumption of meat and dairy products.

**Sweet emptiness**

Besides vegetable oil, another form of 'empty calories' that has been increasing, though much more moderately, is sugar. Its increase is more localised geographically: as shown in Figure 14, North America is the region with the highest level of per capita sugar consumption, and the one where it increased more, though it peaked about the turn of the century and has been decreasing in later years. At about 60 kilos per person/year, the North American consumption of sugar is well above the rest of the world, but it is the only region where sugar consumption has risen significantly. There is no general trend towards more sugary food.

Other regions increased (very moderately) their per capita consumption from 1961 up to the early 1980s, but have remained mostly stable since. Europe, at a similar level of economic development than North America, consumes in fact much less, on a par with Latin America, and both regions have not increased sugar consumption in recent decades (except for the European recovery after the setback of the early 1990s caused by the collapse of the Eastern bloc). Asia and Africa remain relatively stable, well below the world average, and also without any rising tendency in recent decades. The world level of sugar consumption per person/year did increase moderately in the 1960s and early 1970s (from about 20 to about 24 kgpyr) but did not change much since the late 1970s. Thus the regions are grouped in three groups: Asia and Africa at the bottom, consuming about 17 kgpyr; Europe and LAC in the middle at about 40 kgpyr, and North America at the top with 60 kgpyr (after peaking at about 70 at the turn of the century). This pattern is not correlated with level or pace of economic development, but seems to respond to regional (mostly cultural) differences.
Increases in consumption of vegetable oils (observed almost everywhere with the notable exception of Africa) and sugar (which only in North America rose until the turn of the century and remains very high) are the main single food factors in the ongoing epidemic of overweight and obesity affecting a growing share of the world's population. Of the two, vegetable oil is by far the most important.

Figure 14. Consumption of sugar by regions, 1961-2011 (kg/person/year).
Source: FAOSTAT. Includes honey and other natural sweeteners.

Fruit and vegetables consumption

Beyond a lack (or an excess) of dietary energy, the most pressing matter about human nutrition is getting a regular supply of micronutrients, i.e. vitamins and minerals. Some of these are contained in cereals and other staple foods like tubers or pulses, but most come in fruit and vegetables, or are obtained indirectly from food of animal origin like milk, meat, or eggs.

Consumption of fruit and vegetables has consistently gone up during the past half century, in all regions of the world (Figure 15). It grew most spectacularly in Asia, though it actually went initially down there (from 81 to 73 kgpyr) during the 1960s, and then rapidly and steadily grew from a minimum of 73 kgpyr in 1970 to 233 kgpyr in 2011, surpassing all other regions including Europe and North America; most of the Asian growth in this respect (as in others) occurred after 1990. In other regions there was also significant growth in per capita consumption of fruit and vegetables but at more moderate rates. In the North America, long at the top in this regard, the amount per capita peaked in the late 1990s but has slightly declined in later years, meeting by 2011 the level of Europe, somewhat below the level of Asia.

The general increase in consumption of fruits and vegetables, and especially the rapid increase in Asia, portend a general improvement in the intake of micronutrients (vitamins and minerals), a major and often neglected dimension of hunger. There is probably much 'hidden hunger', but the fast growth of fruit and vegetable consumption indicates a tendency towards its gradual reduction.
The superiority of Asia reflects especially its strong growth in consumption of vegetables, where it is lately well above Europe and North America; on the opposite side, Latin America is especially weak in this regard: its per capita consumption of vegetables has been consistently below all other regions including Africa along this entire half century (Figure 16).

On the other hand, consumption of fruit (leaving aside the grapes used for making wine) behaves in a different way. Asia increased it, but much less than in the case of vegetables. Its consumption has also gone down in North America, but not only in the most recent years: it shows a declining tendency since peaking in 1987, and has been recently surpassed by Europe where fruit consumption has been slowly on the rise. In contrast with its low take on vegetables, Latin America and the Caribbean are stronger consumers of fruit, well above the world average. In spite of their modest growth, both Asia and Africa remain below the world mean level, though Asia recently surpassed Africa (Figure 17).
Where's the beef?

Besides fruit and vegetables, other main sources of micronutrients are foods of animal origin, where minerals and vitamins have already been metabolised by animals. Iron, calcium, various vitamins and other essential elements for a healthy diet are found in meat, milk or eggs. This section and the next examine its levels of consumption throughout the world.

Per capita consumption of meats (broadly defined, including also offals as well as fish and seafood) steadily increased from 1961 to 2011 (Figure 18). Increases were concentrated in pork, poultry, and fish and seafood. Per capita consumption of beef and veal has declined after it peaked in the mid-1970s. Consumption of the various items changed at different speeds. Between 1961 and 2011 consumption of beef and veal passed from 9.4 kgpyr in 1961 to 10.8 in 1969, only to return to its initial value in the following years (9.4 kgpyr in 2011). Mutton, goat and other meats also stayed almost constant at about 2.8 kgpyr. Pork nearly doubled, from 8 to 15.5 kgpyr. Poultry increased by a factor of five, from 2.9 to 14.4 kgpyr; offals grew modestly, from 1.6 to 2.2 kgpyr; and fish and seafood doubled from 9 to 18.9 kgpyr. Total consumption of these products strongly increased, nearly doubling from 33.7 to 63.3 kgpyr.

The stagnant and even declining consumption of cattle beef is an interesting bit of data. Consumption of bovine meat is often thought of as a correlate of higher income; the stagnation in per capita consumption of beef and veal during a period characterised by strong growth of income and food consumption, and its steady (albeit slight) decline since the mid-1970s, are slightly surprising and rather counter-intuitive developments in the changing composition of the world's diet: almost all the growth in meat consumption since 1961 did not involve cattle, and two thirds of the increase are accounted for by poultry and fish.
Milk and eggs

Per capita consumption of milk kept an oscillating pattern from 1961 to the early nineties, fluctuating mostly between 76 and 80 kgpyr with a slow long-term rising tendency as each peak in the oscillation went higher than the one before. This pattern was broken since 1993, when milk consumption started a period of steady growth, reaching 92 kgpyr in 2011 without further oscillation (Figure 19).

Regional variation in consumption of milk (see Table 3) is partly explained by ethnic differences in lactose tolerance. Unprocessed milk is tolerated by adults mainly in Northern European and North American countries, as well as in some areas of Eastern Africa and India; most people in Asia and Africa do not have the capacity to metabolise milk except when lactose have been already metabolised by bacterial fermentation (i.e. in the form of cheese or similar processed products).

The amount of eggs consumed yearly per person increased all the time, but growth visibly accelerated since the early 1990s. Worldwide per capita consumption of eggs nearly doubled, from 4.5 kgpyr in 1961 to 8.8 kgpyr in 2011 (Figure 20). This is parallel to the steady rise in per capita consumption of poultry meat, which in the same period grew even faster, passing from 2.8 to 14.2 kgpyr.
Conclusions

This rapid overview of food consumption patterns and regional variation in average diets suggests several overarching conclusions:

- Humans are increasing their average food consumption and improving its dietary diversity, both worldwide and in the each of the various regions.
- The main undesirable tendency is towards increasing consumption of fat, chiefly vegetable oils, a tendency that is most severe in developed countries but also observable in developing ones (with the significant exception of Africa).
- Per capita consumption of cereal food is minimum in North America and maximum in Asia and Africa. Latin America and Europe are (currently) in the middle (Europe was at the top in the 1960s and 1970s but has declined since). Thus the amount of cereal in the average diet is not associated with the level of economic development in any obvious way.
- Per capita consumption of cereal food tends to reach a saturation level. At the world scale all additional calories since 1990 have come from non-cereal food, and average per capita consumption of cereal food has slightly declined. Europe was declining its per capita consumption of food cereal since before 1961 and tended to stabilise since the 1980s; North America peaked around 1980 as did Asia and Latin America; Africa's cereal consumption stalled since the 1990s but is still (very slowly) increasing. The level of cereal consumption at which saturation occurs seems to differ across regions, probably reflecting variation in cultural preferences.
- Meat consumption (broadly defined) is on the rise. However, consumption of beef and veal is generally stable with a small tendency to decrease. The increase is strongly concentrated on poultry, pork, and products of fishery (i.e. fish and seafood).
- Consumption of milk and eggs is also on the rise, as is the consumption of fruit and vegetables. The latter two groups increased especially fast in Asia.
- Sugar consumption per capita has not been significantly on the rise in most regions, at least since the 1980s, except in North America where it has strongly increased and is very high; in that region the level of sugar per capita consumption apparently peaked around the turn of the century and showed a slightly declining trend in more recent years.
- Vegetable oil consumption is on the rise; whilst fats of animal origin also increase, the growth in vegetable oil consumption is much faster, and this is particularly notable in North America (and also Europe) where it has reached very high levels. Africa is the only region not showing a significant rise in the consumption of vegetable oil along the past half century. Asia and Latin America do grow
in this respect but within moderate levels. Thus, unlike the case of cereals, the level and increase of per capita vegetable oil consumption seems directly associated with economic development.

- Consumption of fruit and vegetables is on the rise at the world scale. The most rapid increase has been in Asia, especially in vegetables; Asia consumes nor more than any other region. Europe and Asia consume more vegetables than fruit, whereas Latin America consumes more fruit; North America and Asia consume both in a more balanced way.
TECHNICAL APPENDIX

Regions

Our analysis is mostly based on the FAOSTAT database. The FAOSTAT lowest units of aggregation are individual nations and territories; aggregation of all national data defines the world total, and subtotals for various continental and sub-continental regions. Continental regions are Africa, the Americas, Asia, Europe and Oceania. Examples of sub-continental regions are South America, North Africa, or Polynesia. FAOSTAT data were regrouped for this study into five regions: Africa; Asia/Pacific; Latin America and the Caribbean (LAC); Northern America; and Europe. This required some rearrangement of FAOSTAT data:

- We divided FAOSTAT's 'Americas' region into two sub-regions: 'Northern America' (US and Canada), and 'Latin America and the Caribbean' (LAC); the latter comprises the FAOSTAT sub-regions 'Central America' (which includes Mexico), 'Caribbean' and 'South America').
- FAOSTAT regions 'Oceania' and 'Asia' are merged here, due to Oceania's close relationship with Asia and its relatively small size in terms of population and food production or consumption. 'Asia' in this study thus means 'Asia/ Pacific' though it is most frequently called 'Asia' for the sake of brevity.
- The whole territory of the former USSR, even the areas technically located in Asia, was counted until 1991 as part of Europe. The Russian Federation (including its Asian parts) is still counted in Europe as well as the Western splinters of the former USSR (Ukraine, Belarus and the three Baltic states). However, the Asian splinters of the former USSR (Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan) were counted in Europe until 1991, as parts of the whole USSR, but are classified in Asia since 1992. To ensure comparability over time, in this study those Asian countries are included in Europe (and detracted from Asia). Thus 'Europe' in our study includes not only the Asian parts of Russia, but also the USSR spinoffs in Central and Western Asia.

Food supply-demand accounting

The aggregate amount of food available and consumed, either worldwide or in a particular country or region, is usually expressed by means of certain accounting conventions embodied in supply-utilisation accounts and food balance sheets.

These are ex post accounting identities that necessarily hold. For instance, at any given country the total supply of a given food must necessarily equal all uses of that food (including waste), just as supply must always equal effective or realised demand. Conventions usually applied in food supply-demand accounting are reviewed in this section. The central analytical framework for any food product is the supply-utilisation account (SUA). A derived instrument of analysis is the food balance sheet (FBS) which summarises the SUAs of all food products (FAO 2001).

By being ex post they simply record the realised flows of production and utilisation of food, and do not contain predictions of microeconomic decisions about production or use that would be made by producers and consumers on the basis of individual preferences or cost-benefit calculations. By being descriptive, they quantify actual flows of production, trade or consumption, without any normative implication. In particular, they do not involve norms about how much or what kind of food is required to supply necessary nutrients or to maintain good health: the figures simply summarise what is actually produced, traded or consumed. The results may always be compared to normative requirements in order to assess any possible deficit, but that is not part of food supply-demand accounting as such.

Supply-utilisation accounts

Within the boundaries of a given country, sub-national region, community, or household, and in a given period, food becomes available in three different ways: it can be (a) produced internally during the same
period, (b) acquired from outside sources, or (c) drawn from pre-existing carryover stocks. Once made available in some of these ways, food can be used (or wasted) in various forms: it may be (a) consumed as human food, in raw or processed form; (b) fed to animals; (c) lost or wasted; (d) stored away for future use; or (e) moved out of the boundaries of the unit considered (e.g. exported). This gives rise to the notion of an aggregate food budget, comparing availability and utilisation of food products, also called supply-utilisation account (SUA) or commodity balance. Such SUAs or balances may be estimated also for non-food products such as wool or tobacco (see for instance FAO 2003b). The SUA is a flow measure, representing the amount of a product made available or used during a given period (usually a year). The annual SUA of a given commodity i (e.g. wheat), expressed in physical terms (tonnes) and commonly computed at the national level for a given year, is expressed by the following ex post identity:

\[
\text{Supply-Utilisation Account (SUA) for a given product, period and country}
\]

\[
\text{Domestic supply of product } i = \text{ Domestic utilisation of product } i
\]

\[
DS_{ijt} = DU_{ijt}
\]

\[
S_{oijt} + P_{ijt} + M_{ijt} - X_{ijt} = F_{ijt} + U_{ijt} + S_{cijt}
\]

The domestic supply \( DS_{ijt} \) of a specific product i (e.g. wheat), in a certain period t (normally a year) and country j is the sum of the opening stocks of that commodity \( S_{oijt} \) plus domestic production during the period \( P_{ijt} \), plus imports \( M_{ijt} \), minus exports \( X_{ijt} \). Domestic utilisation (or effective domestic demand) \( DU_{ijt} \) at the same country and for the same product and year is the sum of the amount available for human food consumption \( F_{ijt} \) plus the amounts allocated to other uses \( U_{ijt} \), plus any final or closing stocks \( S_{cijt} \). Other uses \( U_{ijt} \) include all non-food uses of the product, i.e. its use as seed, animal feed, and input for non-food industries (e.g. biofuels), plus waste or losses. For some purposes these non-food uses may be more explicitly distinguished, e.g. to analyse food waste, but on other situations they may be considered as a whole amount to be detracted from gross supply in order to get an estimate of food effectively available for human consumption.

Availability for human food consumption in FAOSTAT SUAs reflects apparent food consumption, i.e. amounts of food products delivered to consuming units, chiefly households but also other feeding places (restaurants, hospitals, schools, barracks, jails, etc.), which are for this purpose equated to households. The SUA formula takes account of post-harvest waste and losses, but only 'up to the household gate', i.e. during the marketing and processing chain: see for instance FAOSTAT's Frequently Asked Questions (http://faostat.fao.org/site/565/default.aspx, question 7): 'Consumption in the Food Balance Sheets refers to consumption at the household gate'. In the same vein, FAO's methodology for estimating undernourishment is based on the daily dietary-energy supply (DES) at the household level: 'the daily per person DES refers to food acquired by (or available to) the households rather than the actual food intake of the individual household members' (FAO 2008:9).

Thus, apparent consumption includes food waste occurring within households or within other consumption units such as restaurants or hospitals. Such waste may include food decaying while held in household storage, food lost to vermin, kitchen and plate leftovers, food used for pet feeding, etc. There are some estimates of household food waste, but they are not as yet incorporated into FAO food balance sheets. For a given estimate of apparent consumption, actual food intake by individuals is thus likely to be somewhat lower on account of household waste. \( F \) in the formula above is thus a measure of food available to households, i.e. food the household has access to, as measured 'at the household gate', albeit not necessarily consumed in its entirety by household members. It is variously called 'food supply' or 'apparent consumption', and is often computed as a residual once the other quantities are estimated empirically. Thus the apparent consumption of a given food product i for country j at year t is:

\[
F_{ijt} = S_{oijt} + P_{ijt} + M_{ijt} - X_{ijt} - U_{ijt} - S_{cijt}
\]
Instead of estimating it as a residual, direct estimates of \( F_i \) based on household surveys are sometimes used, but such surveys (often based on verbal recall or on household record-keeping in a particular day or week) are known to underestimate actual consumption (FAO 2003a).

All figures in the SUAs are annual flows during period \( t \), except as regards opening and closing stocks. Obviously, the closing stocks of year \( t \) equal the opening stocks of year \( t+1 \). In practice, stock change is the relevant flow variable, and the formula, as usually given, replaces both initial and final stocks by a single flow variable (\( S \)) representing stock change:

\[
S_{ijt} = S_{cijt} - S_{oijt}
\]

Likewise, foreign trade may be also simplified in a similar manner, replacing \( M_{ijt} \) and \( X_{ijt} \) by net exports or trade balance for each product, denoted here by \( T_{ijt} \):

\[
T_{ijt} = X_{ijt} - M_{ijt}
\]

In terms of this treatment of trade and stocks, the previous formula for \( F_i \) becomes:

\[
F_{ijt} = P_{ijt} - T_{ijt} - U_{ijt} - S_{ijt}
\]

The above equation is in fact an accounting identity representing the ex post demand-supply balance of a given commodity. It may refer to any level of aggregation: the world, world regions, countries, sub-national regions, and local communities. An analogous identity holds also at the level of individual households: \( P \) would stand for household food production, if any, e.g. output from a family farm or kitchen garden, whilst \( M \) and \( X \) would respectively stand for food entering or leaving the household (including purchases and sales, and also transfers and donations). In the same vein, stock change \( S \) at the household level would refer to changes in the contents of the household’s pantry.

At the world level the trade balance of each commodity \( (T_i) \) is in principle (or theoretically) zero, since world exports must equal world imports (except for statistical discrepancy). Instead, the trade balance of a product for a single nation (or household) should not in principle be (and is usually not) zero; the two trade flows \( (M \) and \( X \)) are important when the definition is applied to specific countries. Besides, though in principle the world’s trade balance should be zero, empirical data on total world exports do not usually match total world imports due to various sources of statistical discrepancy (smuggling, varying accounting principles applied for free zones or for re-exporting, etc.). See Supplementary Information of Malletta 2014c for a discussion.

Total supply in given period (usually a year) for a given geographical area (country, region, world) may be divided by the corresponding population to estimate per capita supply, usually presented in terms of physical yearly quantity of each product (kg/person/year) or in terms of its contents of protein and fat (in grams/person/day) and dietary energy (kilocalories/person/day). FAO SUAs refer to calendar years, but the original information provided by countries usually refers to the agricultural year, variously defined across countries (e.g. July 1 to June 30, or April 1 to March 31); FAO uses information on the growing season for each crop in order to estimate production per calendar year.

SUAs estimate the total and per capita amount of food available for human consumption, but not its (possibly unequal) distribution across the population. Distribution among households can be gauged in household consumption or expenditure surveys, or estimated by other means. As SUAs and household surveys estimate the amounts of food available for consumption at the household gate, they do not reveal the intra-household distribution of food among household members. Household consumption or expenditure surveys seldom investigate actual intake of food by individual members.

**Food balance sheets**

FAOSTAT contains separate SUAs for each product (by country and year) and also annual comprehensive food balance sheets covering all food products in a given year and for a given country or region. Food balance sheets are computed, for each particular food, in physical terms (usually in tonnes), and are not valued or aggregated in economic terms. Physical quantities cannot be aggregated, except for
similar products (e.g. cereals). However, food balance sheets include aggregate estimates of daily per capita supply of fat, protein and dietary energy.

Food balance sheets, like SUAs, are often expressed in terms of primary commodities (e.g. wheat); imports of processed products (e.g. flour or pasta) are converted into the amount of the primary commodity or commodities that went into their production, by application of some conversion coefficients; thus imported wheat flour is converted into wheat grain equivalent, and imported powder milk into fluid milk. Sometimes a processed product contains more than one primary product; for example, imported cookies may be converted into appropriate amounts of wheat, butter, and sugar (see FAO 2001, the FAO handbook on food balance sheets).

A typical food balance sheet includes one line per product, and columns for domestic production, trade flows, stock change, domestic availability (P-X+M-S), losses or waste, use as feed or seed, other non-food uses, and food supply, all flows expressed in tonnes per year. The food supply of each food item (e.g. wheat, green peas, or beef) is also calculated in per capita terms (kg/person/year) and converted into the corresponding daily amounts of energy, protein, or fat according to food composition tables. Estimates of per capita availability of major nutrients, such as protein and fat are given in daily grams per person, and dietary energy in kcal/person/day.

<table>
<thead>
<tr>
<th>Calories and joules: How dietary energy is measured</th>
</tr>
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<tbody>
<tr>
<td>Dietary energy may be alternatively measured in calories or joules. A kilocalorie is defined as the amount of energy required at sea level to heat one litre of pure water by one degree Celsius (more precisely from 14.5°C to 15.5°C). One kilocalorie (which is frequently called a ‘calorie’ in the context of food) equals 1000 'chemical' or 'small' calories, which have the same definition but referred to a millilitre of water (a volume of one cubic centimetre). However, in common parlance about food, kilocalories are often called 'calories' for short. This study discusses dietary energy in terms of kilocalories (abbreviated as kcal) because they are the most commonly used unit in this context, but the international unit of energy is the joule, and it is recommended (FAO 2004) that joules should be used also for food, gradually replacing calories.</td>
</tr>
<tr>
<td>A joule is defined in terms of the international unit of force, the newton, which is the force required to accelerate a mass of one Kg by one metre in one second. A joule is the work performed by a force of one newton to displace its point of application by one metre in the direction of that force. One kcal = 4.184 kilojoules (kJ), and one kJ = 0.239 kcal. The estimated dietary energy content of a particular food item is based on the energy the body can extract from its contents of carbohydrates, fat, protein and ethyllic alcohol, the only substances the human body can use as sources of energy; these substances provide energy according to the Atwater coefficients (approximately 4 kcal/gram for carbohydrates and protein, 7 for alcohol, and 9 for fat). For details see FAO 2003a, FAO 2004, and Shetty 2005.</td>
</tr>
</tbody>
</table>

FAO food balance sheets do not provide estimates for vitamins and minerals, and also fail to provide an explicit account of the supply of carbohydrates, but the latter can be estimated by difference, deducting from total dietary energy the energy contained in protein (4 kcal per gram), fat (9 kcal per gram), and alcoholic beverages (as indicated in the respective line of the FBS) at 7 kcal per gram. The energy provided by carbohydrates, once estimated, can be converted into carbohydrate quantity at a rate of 4 kcal per gram. Daily per capita amounts of dietary energy, protein, and fat are aggregated in the first few lines of the FBS, for all food items and also for major subsets such as vegetal and animal products.

**Food aid and ex-ante food balances.** Humanitarian food aid may or may not be counted as part of aggregate food availability, depending on the purpose of the analysis. Normal *ex post* SUAs count food aid as part of trade flows, but food aid is often excluded in *ex-ante* or *prospective* food balances. These prospective balances aim at estimating whether the expected food supply will be sufficient to meet expected demand in the short term (e.g. over the current or next agricultural year). If the goal is measuring the autonomous capacity of the reference unit (nation, region, community) to have enough food, or determining how much food aid would be needed, then food aid should *not* be included in food supply. In *ex-ante* SUAs, usually restricted to cereals or other staple foods, terms are arranged differently, isolating food aid needs as an **expected uncovered gap** of commodity $i$ for country $j$ and year $t$, denoted as $G_{eijt}$:

$$G_{eijt} = S_{oijt} + P_{eijt} + M_{eijt} - X_{eijt} - U_{eijt} - F_{hijt} - S_{eijt}$$
$G_{ejit}$ refers to the expected gap of commodity $i$ in the coming season, to be covered by food aid; $S_{ejit}$ stands for the opening stocks of commodity $i$; $P_{ejit}$ is the expected level of production; $F_{ejit}$ is the expected habitual level of food supply of $i$ (defined as habitual per capita supply in normal years, multiplied by expected population of the target period); $U_{ejit}$ is the expected amount to be devoted to other uses (including losses); $M_{ejit}$ and $X_{ejit}$ are the expected commercial trade flows, perhaps including 'structural' or 'programme' food aid that is regularly received but not related to the current emergency; and $S_{ejit}$ is the desired or planned level of closing stocks at the end of the period envisaged. Methodological details can be found in the FAO-WFP guidelines for crop and food supply assessment missions (FAO/WFP 2009).

The present study is not concerned with ex-ante food balances, intended to determine food aid needs. We restrict our analysis to ex-post SUAs and food balances, showing actual (realised) availability and apparent consumption. FAO ex-post SUAs (commodity balances) and food balance sheets, included in the FAOSTAT database, do include food aid as an integral part of trade flows (special FAOSTAT data are also available on food aid flows). Unlike ex-ante or prospective balances, ex-post SUAs are identities, which are always balanced by definition: ex-post total supply equals ex-post total utilisation, without any 'uncovered gap'.

References


