Report

Future diets

Implications for agriculture and food prices

Sharada Keats and Steve Wiggins

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Key messages

- Over one third of all adults across the world – 1.46 billion people – are obese or overweight. Between 1980 and 2008, the numbers of people affected in the developing world more than tripled, from 250 million to 904 million. In high-income countries the numbers increased by 1.7 times over the same period.
- Diets are changing wherever incomes are rising in the developing world, with a marked shift from cereals and tubers to meat, fats and sugar, as well as fruit and vegetables.
- While the forces of globalisation have led to a creeping homogenisation in diets, their continued variation suggests that there is still scope for policies that can influence the food choices that people make.
- Future diets that are rich in animal products, especially meat, will push up prices for meat, but surprisingly, not for grains. This suggests that future diets may matter more for public health than for agriculture.
- There seems to be little will among public and leaders to take the determined action that is needed to influence future diets, but that may change in the face of the serious health implications. Combinations of moderate measures in education, prices and regulation may achieve far more than drastic action of any one type.

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Abbreviations

ADER	Average Dietary Energy Requirement
BMI	Body Mass Index
CAR	Central African Republic
CDC	Centers for Disease Control
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement
EBT	Electronic Benefit Transfer
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Statistical service of FAO
FD	Food Deficit
FDF	Food and Drink Federation (UK)
FDI	Foreign Direct Investment
FSU	Former Soviet Union
FY	Fiscal Year
GAEZ	Global Agro-ecological Zones
GDA	Guideline Daily Amount
GDP	Gross Domestic Product
GNP	Gross National Product
HIC	High-income country (ies) – World Bank definition
HIP	Healthy Incentives Pilot (USDA SNAP)
IDH	Ischemic heart disease (most common type of heart disease & cause of heart attacks)
IFPRI	International Food Policy Research Institute
IIASA	International Institute for Applied Systems Analysis
IMPACT	International Model for Policy analysis of Agricultural Commodities and Trade

INRA	Institut national de la recherche agronomique
IP-TFA	Industrially-produced trans-fatty acids
kcal	kilocalorie
KFC	Kentucky Fried Chicken
Kg / g	kilogram / gram
LAC	Latin America and the Caribbean
LIC	Low-income country(ies)
MENA	Middle East and North Africa
MIC	Middle-income country(ies)
NCD	Non-communicable disease
NHS	National Health Service
NNNP	Norwegian National Nutrition Policy
OECD	Organisation for Economic Co-operation and Development
SNAP	Supplemental Nutrition Assistance Programme (USA)
SSA	sub-Saharan Africa
Starchy roots	Root vegetables rich in complex carbohydrates such as potato, cassava, yam
t	tonne = metric tonne
Trans-fat	A fatty acid present in many man-made foods, implicated in heart disease
UN	United Nations
USDA	United States Department of Agriculture
VAT	Value-added tax
WHO	World Health Organization of the United Nations
WWI	First World War
WWII	Second World War

Executive summary

Issues and concerns

Diets are increasingly important in a world of economic growth and rising incomes. And two concerns, in particular, are emerging: the effect of diet on health; and the demands made by changing diets on agriculture. The impact is most marked in the developing world, where we now see both the fastest acceleration in over-consumption and the greatest continuing toll of under-consumption.

The over-consumption of food, coupled with lives that are increasingly sedentary, is producing large numbers of people who are overweight and obese – primarily in high-income countries, but also in emerging middle-income countries. Indeed, the world has seen an explosion in overweight and obesity in the past 30 years. Globally the percentage of adults who were overweight or obese grew from 23% in 1980 to 34% in 2008, with the vast majority of this increase seen in the developing world. Here, the numbers of people affected more than tripled from around 250 million people in 1980 to 904 million in 2008. By contrast, the number of people who were overweight or obese in high-income countries increased 1.7 times over the same period (Stevens et al., 2012).

The evidence is well-established: obesity, together with excessive consumption of fat and salt, is linked to the rising global incidence of non-communicable diseases including some cancers, diabetes, heart disease and strokes. What has changed is that the majority of people who are overweight or obese today can be found in the developing, rather than the developed, world.

At the same time, under-consumption of dietary energy, protein and micronutrients is still a problem for hundreds of millions of people. Again, most of them are in the developing world, where the greatest concern is the inadequate nutrition for infants that impairs their mental and physical development and puts them at a life-long disadvantage. Progress on reducing the incidence of stunting amongst children has been slow: it is still thought that up to one-third of infants in the developing world are stunted. Increasingly, however, the wider concern is less about macro-nutrition and more about micro-nutrition: the lack of key minerals and vitamins – particularly iron, iodine, vitamin A and zinc – that affects an estimated 2 billion or more people.

Diets also matter for future demand for food. It should be easier to feed the expected global population of 8 billion in 2030, and 9 billion in 2050, if diets are moderate rather than high in livestock consumption. Any additional production of meat and dairy will probably have to come, in large part, from feed grains, with less energy consumed from grain and more from meat and milk. High demands for feed grains in the future will put pressure on land, water and fertiliser supplies, drive up costs of agricultural production, and make it more difficult for those on low incomes to afford an adequate diet.

Given this scenario, this report addresses three sets of questions.

- How far do diets vary between countries? What is known about the reasons for the marked differences seen in diets? How far can the differences be attributed to income?

- Are there examples of public policies that have had a real impact on choice of diet, and if so, which polices have been most effective and under what conditions?

- How big will the gap be between the food available and the food that is needed in the future, if diets shift to match those recommended by nutritionists, rather than converging to resemble the diets seen in North America or Western Europe? And what are the implications for the prices of staple foods?

These have been addressed by reviewing the existing literature and by analysing data and statistics on food consumption worldwide, by major region, and for five middle-income countries selected to show how diets have changed over the past 50 years as a result of economic growth and urbanisation.

Diets and their determinants

The world has seen appreciable increases in the amount of food available per person over the past half century, across all food groups. For people on high incomes, food has become so abundant that they can choose their diet with few concerns over cost. As economic growth, rising incomes and urbanisation have taken place, diets have tended to follow. Typically they shift from the heavy consumption of grains and starchy staples to meet people's daily energy needs at a minimum cost, to the partial replacement of staples by more fruit and vegetables, but above all by more animal produce, oils, fat and sugar.

While such general patterns are evident, there is still plenty of variation among countries – a reflection of national food cultures and preferences – and there is further variation within countries by economic and social group and by district.

When we compare current diets to those recommended for healthy and active living, we find that diets across the world have more than enough grains, but are usually low in dairy and fruit. In high-income countries, such as the US, the consumption of oil, fat and sugar is well above recommended levels. At the other end of the scale, the world's least-developed countries have average diets that fall far short of the recommended levels of fruit, vegetables, dairy and other protein-rich foods such as fish and meat.

Many factors influence a person's diet. They can be grouped in half a dozen categories: human biology and physiological needs; the costs of food and level of income; preferences formed by culture, religion, information and advertising; social changes in work patterns and gender roles; and globalisation and its influences through trade, investment and information; and public policy.

Perhaps the most interesting question here is the extent to which growing incomes and globalisation are leading to the convergence of diets on some international norm or, conversely the extent to which diets remain heterogeneous by country, social group and individual. It would be perverse to deny that rising incomes and urbanisation tend to lead to diets rich in animal produce, fat, salt and sugar, or that the various influences of globalisation, including advertising and media, can have significant impact on diets. Yet it seems that national diets are not necessarily converging on a single international norm. In fact, income may be becoming a weaker determinant of diet over time. The welcome implication is that there may be considerable scope for public policy to have a real influence on diets.

Types of policy

Many policies and public investments influence diets indirectly – above all by affecting the price of food – through, for example, policies that promote agricultural development, or public investments in roads and ports that support improved logistics and lower unit costs for food distribution. The focus here, however, is on specific measures that have specific dietary objectives.

Policies for diets can be categorised by the means used, dividing them into: information designed to affect individual choice of foods; price incentives to change the cost of all or specific foods, plus income measures to make foods more affordable; and restrictions and rules on food processing, advertising and retailing.

One example of using persuasion to influence diets can be seen in South Korea's efforts to preserve healthy elements of the country's traditional diet in the face of a nutrition transition. Public campaigns and education, including the large-scale training of women in the preparation of traditional low-fat, high-vegetable meals, has led to Korean diets that resulted in the consumption of more of these meals than might be predicted, given the country's relatively high average incomes. An example of stronger regulation can be seen in Denmark's 2004 ban on trans-fatty acids (TFA), which are useful in food manufacturing but considered to carry high risks for cardio-vascular disease – a move that has reduced the country's prevalence of heart disease.

A second division can be made between those measures that seek to remedy the undernutrition that is still concentrated in the developing world and those that try to encourage the consumption of healthy alternatives to reduce the consumption of foods that can, when consumed to excess, lead to obesity and illness.

Projections of future needs for food

The rather surprising result of modelling by the International Food Policy Research Institute (IFPRI) is that varying the projected future levels of meat consumption has only a modest effect on the amount of feed grain required, and next to no effect on staple grain prices – even if it does have a strong effect on the amount of meat produced and on meat prices. This is all the more surprising, given that IFPRI's low-meat scenarios envisage that high-income countries plus Brazil and China will cut their meat consumption to half of the levels expected in the future (even below current levels). In other words, these scenarios assume strong and effective public policy, beyond what may seem feasible in the near future.

Discussion

Three key issues emerge from this study, even given imperfect evidence, with implications for public policy and especially for future agricultures and food costs.

First, diets and their influences are more varied than some may imagine. Yes, the combined forces of economic growth, rising incomes, urbanisation and globalisation are powerful, but we should not underestimate the extent of local variation. Bear in mind that it has not been possible in this review – for lack of readily available data and time – to look at diets at a level more detailed than national average consumption. It is known that even within national templates there are wide variations by income groups, by regions within countries, and by other social variables such as vegetarianism and culinary traditions. So, getting closer to the grain of reality would reinforce this message of variety and the limits to which growth and globalisation may lead to homogenous diets.

The implications are two-fold: that globalisation will not, in the medium term, place massive restrictions on the scope for policy action; and that policy needs to start where people are at present in terms of their diverse preferences and traditions. Trajectories are not pre-ordained; there is scope to influence the evolution of diet to get better outcomes for health and agriculture.

Second, IFPRI's modelling reveals some surprising results. Indeed, one of the reasons we run models is to check for such surprises. Meat consumption that seemed *a priori* to matter immensely for future agricultures in terms of demand for feed grains and, by extension, the cost of many foods, turns out to be less important in this regard than imagined. At the margin, of course, lower meat intakes in high-income and emerging economies would make it easier and cheaper to grow food in the future. It would almost certainly lead to a fairer world in that it would allow relatively low meat prices for people on low-incomes in developing countries.

This implies that lower meat consumption does not matter quite so much from an agricultural point of view, nor from our original concern – the cost of staple foods. But that does not mean that meat consumption, and the consumption of dairy and some fish, does not have public importance. It means,

in fact, that the more important public concerns probably lie with better health. Studies such as that of Cecchini et al. (2010) show large benefits compared to costs from measures to influence people to adopt healthier diets. The prime concern of such measures relates to the intakes of fibre and fat, which may be linked only partly to animal-produce consumption, but they are certainly linked. There may also be good reasons to limit the livestock economy on environmental grounds, not least to restrict emissions of greenhouse gases; although we did not have the time to assess the growing literature on this consequence of diet.

Third, we can see a paradox of public policy. In general, there is little appetite amongst politicians or the public in high-income countries to take strong measures to influence future diets. Politicians are fearful of meddling with diets, and alienating farming and food-industry interests. It seems that this reflects public opinion, with many people seeing food choices as a matter of personal freedom. Most people hate to see regulation of their access to favoured foods, see taxation of unhealthy foods and ingredients as onerous and unfair, and acquiesce only in response to public information and education. Couple this with lobbying from food industries, and the political will to affect diets withers.

Yet against this we must set the growing scientific consensus that sees some aspects of diets in OECD countries – and above all the excessive consumption of fat, salt and sugar – as significant contributory factors to some cancers, cardio-vascular disease and diabetes. Tentative models of the benefits of better diets on public health show many advantages. Yet the continued lack of will to act on diet stands in marked contrast to the concerted – and largely effective – public actions that have been taken to limit smoking in OECD countries. Looking at the range of policies on offer, it seems that regulation and taxation are the most effective policies for diet, but these are precisely the policies that are least palatable to both the public and politicians.

In fact, policies on diets have been so timid to date that we simply do not know what might be achieved by a determined drive to reduce the consumption of calories, and particularly the consumption of fat, salt and sugar, in OECD countries. This has never been attempted, with the rare exception of the wartime rationing in Britain, which stands out as an unusual natural experiment that led to better health; but one that the British public were delighted to abandon once supplies had been restored after the Second World War.

While current policies and action on diets may be hesitant and timid, that does not mean that governments should always be so cautious, even if their caution reflects the public mood. When taking action to limit smoking, governments have often led the way, driven by the strong evidence from medical studies showing the harm caused by cigarettes. Although diet is a more diverse and complex issue than smoking, there may be scope for government to take more incremental measures, perhaps using measures in combination, to pave the way for public acceptance that something needs to be done if future health costs are to be contained.

At some point in the future there may well be an international debate over meat consumption and what fair shares of meat can be produced at relatively low cost and within the limits of environmental sustainability and greenhouse-gas emissions.

A final comment (and paradox): interest in diet has never been stronger in high-income countries as we obsess about our waistlines, worry about the social impacts of the marketing strategies of (very) large food retail chains, and enthuse over the culinary art and tradition shown in countless television programmes. Scientifically, a plethora of papers have been drafted in the past 10 years that ponder the rise of obesity worldwide and its implications.

It seems, then, that it is only a matter of time before people will accept and demand stronger and effective measures to influence diets. When that time comes, we will need the evidence – provided in a very preliminary way by this review – on the main problems of emerging diets, and which policies (and combinations of policies) will be most effective in addressing the emerging challenges.

1 Introduction: increasing concern over diets

Concerns

How people choose their food and select their diets is growing in importance in a world of economic growth and rising incomes. Two major concerns are emerging: health and nutrition; and demands on agriculture.

Diet matters for ***health and nutrition***, because an adequate diet:

1. allows children to grow to reach their physical and mental potential
2. allows the everyday, active and healthy functioning of everyone – child or adult, and
3. reduces the risks of diet-related diseases – increasingly important in a world where the threat of infectious disease is diminishing when compared with the rise of non-communicable disease.

As many as 800 million people may currently suffer from deficiencies of energy and protein, but these numbers will probably fall as poverty falls, as seen in countries benefiting from broad economic growth – often in the wake of a 'green revolution' in agriculture that has increased food production ahead of population growth. China is one of the best examples: following the reforms of 1978, both poverty and insufficient food availability have fallen dramatically, resulting in greater food security and better nutrition.

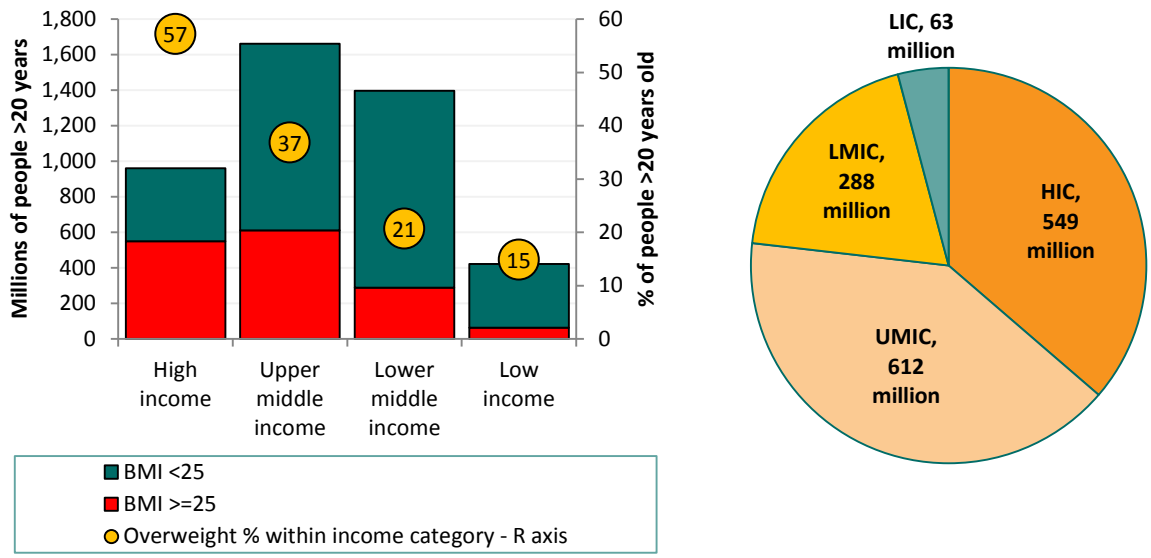
Increasingly, the challenges for nutrition lie in two areas. One is tackling the micronutrient deficiencies believed to affect as many as two billion people – important not only in their own right, but also for the ways in which higher levels of some micronutrients enhance the absorption of macronutrients. The other, and increasing concern, is reducing the tendency to obesity and the rise of diseases related to diets that are too high in energy, fat, salt and sugar – including coronary heart disease, diabetes, strokes and some cancers. Until recently, these non-communicable diseases were largely a concern for high-income countries, but they are now seen increasingly in the developing world where overweight and obesity are rising at a rapid pace.

Globally, 34% of adults[1] are estimated to have a Body Mass Index (BMI) of 25 or greater, and are, therefore, overweight or obese.[2] While the prevalence of overweight or obese people is greater in high-income countries, most of those affected live in the developing world, see Figure 1.1.

[1] Derived from WHO statistics for crude overweight and obesity prevalence for adults in 2008, multiplied by population of adults in 2010 according to UN estimates.

[2] BMI is calculated by dividing a person's weight in kilograms by the square of their height in metres, yielding an approximation of whether someone is over- or underweight.

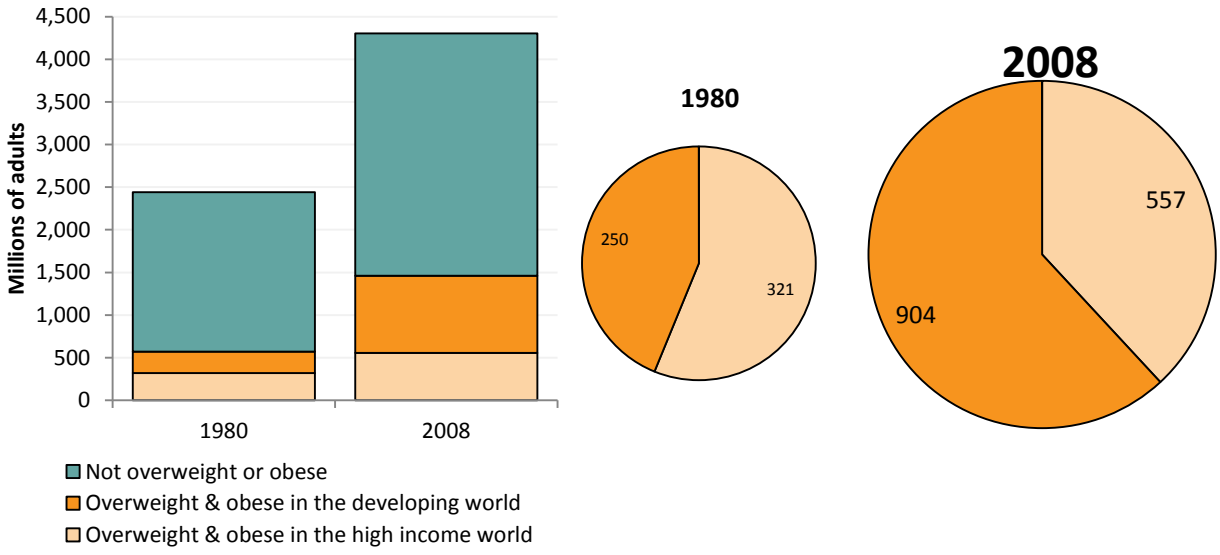
Figure 1.1 Estimated number of overweight and obese adults by type of country



Source: WHO statistics for overweight and obese adults for 182 countries for 2008; population estimates from the United Nations Population division for 2010.

The percentage of people who are overweight or obese has risen in the past 30 years (Figure 1.2), from 23% in 1980 to 34% in 2008. The increase has been particularly strong in the developing world, where the numbers of people affected more than tripled from around 250 million people in 1980 to 904 million in 2008.

Figure 1.2 Explosion in the number of overweight and obese adults from 1980 to 2008



Source: Data from Stevens et al., 2012

More sedentary lives exacerbate the problems of over-consumption of food. As a result, what was once seen as a rich-country burden now constitutes a growing problem worldwide:

> *'… because patterns of food consumption are a major modifiable risk factor for three of the most common types of chronic non-communicable diseases: cardiovascular disease, diabetes, and some cancers. Six risk factors related to nutrition (including high blood pressure, high blood glucose, overweight, and obesity) account for 19% of deaths worldwide. A rapid increase in the burden of chronic disease is affecting populations at all stages of economic development, and 80% of all deaths from chronic disease now occur in low-income countries.' (Lock et al., 2010)*

The same authors conclude that:

> *'In response to rising burdens of these diseases, a major global health emphasis is needed to develop and implement policies to secure a healthy diet.'*

Major concerns over diets arise, therefore, in relation to both the under- and over-consumption of food, as summarised in Table 1.1.

Table 1.1 Food consumption: current concerns for health and nutrition

Criterion	Too little	Too much
Food to allow children to grow to reach their physical and mental potential	Insufficient infant nutrition in both macro- and micronutrients still a major concern in developing countries, and above all in low-income countries.	Child obesity a concern in high-income countries, but increasingly seen in middle-income countries. [The Barker hypothesis* sees problems of maternal undernutrition as a potential cause of obesity later in life.]
Food to allow adults to have an active and healthy life	Insufficient adult energy intake still seen amongst the very poor in the developing world. More widespread micronutrient deficiencies leading to conditions and diseases that cause illness, disability and death.	Overweight and obesity and its relation to disease a concern in high-income countries, but seen increasingly in middle-income countries.
Balanced diet avoiding over-consumption of energy, fat, salt and sugar to reduce risks of diet-related diseases	Some diets, while sufficient in energy, may lack micronutrients owing to under-consumption of fruit and vegetables, fish or dairy.	Increased risks of some cancers, diabetes heart disease, and strokes. Major concern in high-income countries, but increasingly seen in middle-income countries, with lesser incidence in low-income countries.

Source: Own elaboration.

*Note: *See Barker DJB, ed. 1992. Fetal and infant origins of adult disease. London: BMJ Publishing Group.*

Demands on agriculture. It should be easier to feed the expected global population of 8 billion in 2030, and 9 billion in 2050 if diets are moderate rather than high in livestock consumption

(Government Office for Science, 2011a; FAO, 2009). Additional production of meat and dairy will probably have to come in large part from feed grains such as maize, sorghum and soybeans. Because of the low energy conversion ratios of feed grain into livestock (at best five to two) the cultivation of these needs to expand disproportionately for each marginal increase in livestock-product energy. This escalates the physical consequences for resources in terms of the larger areas that need to be cultivated, greater use of mineral fertiliser, more application of irrigation water and more use of pesticides. The costs of production will increase accordingly, both for feed grains and for grains and other staple products intended for direct human consumption, as the marginal costs of these resources will rise in many places and cases. Increased food costs will delay the point at which poor people, and especially those who are very poor, are able to consume a diet that is sufficient in calories, protein and varied enough to cover their needs for minerals and vitamins.

At present, the world's supply of food is far from ideal for nutrition, either by composition or distribution. Although supplies of some foods like carbohydrates, proteins, and oils are adequate, supplies of fruit and dairy are well below any of the varying recommended levels. Of more concern, of course, is that the unequal distribution of this food means that individual diets are often far worse than might be implied by global averages. Therefore, meeting the needs of those people who are deficient in foods such as animal produce will mean producing more, even if there is already enough meat worldwide – if not dairy – to meet current needs.

Questions addressed and method

This prompts the following questions that will be addressed in this paper:

- How far do diets vary between countries and why? How much of the variation can be attributed to income?
- Are there examples of public policy having a significant impact on choice of diet, and if so, which policies and why?
- How big will the food gap be in 2030 if people worldwide choose the diets recommended by nutritionists rather than the diets seen today in North America or North-western Europe? And what will be the implications for the prices of staple foods?

These questions have been addressed by reviewing the existing literature. Statistics on food consumption worldwide, by major region and by selected country have been compiled from available sources, and in particular from the FAOSTAT database hosted by the United Nations Food and Agriculture Organization (FAO). Key measures of diet examined include energy (kilocalories), protein, and fats, as well as a breakdown of important food groups. The consumption of animal products was one focus, given the disproportionate pressure this can exert on agricultural resources.

Five current middle-income countries (MICs) were selected as case studies to illustrate dietary trends in the developing world over the past 50 years: China, Egypt, India, Peru and Thailand. MICs were selected because it is in these countries, as they have moved from low to middle incomes, that the most striking changes in diets have been seen in the past half century. The five countries were selected to represent: one with a high proportion of food supply from animal-sources relative to other MICs (China); one with a low proportion of food supply from animal-sources (India); then three with a moderate proportion of animal-source food consumption (Egypt, Peru and Thailand), with the five countries chosen to give some representation across regions. It would have been interesting to have a country from sub-Saharan Africa, but only a few countries have moved from low- to middle-income status in the past 50 years and most of these are small countries such as Botswana, Equatorial Guinea, Gabon and Mauritius — which, other than the last named, have unusually high amounts of valuable minerals, oil and gas per person.

The next chapter looks at diets across the world, how they have changed through time in dietary transitions, and the factors that influence diets. Given the great interest in how globalisation affects diets, this section concludes with an assessment of the influence of processes of globalisation – trade, foreign direct investment and information – on diets, as compared with other factors.

The third chapter focuses on public policy to affect diets directly, looking at the type of policies used, their incidence and what is known about their effectiveness and under what conditions.

Chapter four examines three modelling exercises that address some of the questions posed in this paper and reveals some surprising results from an exercise conducted by the International Food Policy Research Institute (IFPRI) that comes close to responding to the questions set.

The fifth and final chapter concludes by summarising and discussing the findings.

2 Diets: differences and changes through time and influences

This chapter looks at diets and how they have evolved since the 1960s, taking averages for the world as a whole, as well as major regions, and selected countries. The overview provided, using FAO's statistical databases, looks first at kilocalorie supply and the proportion of kilocalories from animal versus vegetable sources, before examining supply by weight for food group, in particular those from animal sources, fruits and vegetables, starchy staples, fat and sugar. Because 'supply' is calculated on the basis of FAO estimates for human food (having already subtracted foodstuffs produced for other uses including animal feed, waste, stocks, or industrial uses), it is close to consumption – the difference being any food lost in preparation or wasted.

The diets observed are compared to recommended food intakes. The factors that influence these diets are then reviewed, followed by consideration of their actual impact on diets and hence the scope for public policy to guide personal choice.

Diets observed

Food energy

All moderately active adults need between 2,500 to 3,000 kilocalories (kcal) each day to sustain them,[3] with this range reflecting variations in their needs by age, sex, activity, pregnancy, health and their existing nutritional status. In 2010-2012, most (156 of 175) countries had average per capita food energy availability[4] of 100% or more of the estimated amount required. Only 19 had below 100% of the estimated requirements: 14 of them in Africa.[5] Available dietary energy has increased since 1990-

[3] A woman 170cm tall weighing 70kg who is moderately active requires around 2,400 kcal/day if she is 18 and around 1,948kcal/day if she is 80. If she is extra active, at 18 she will need around 2,942 kcal/day and at 80 around 2,300 kcal/day. A man 180cm tall weighing 80kg who is moderately active, will require 3,006 kcal/day at 18 and around 2,353kcal/day at 80. If he is extra active, he will require 3,685 kcal/day at 18 and 2,884 kcal/day at 80 years of age. See http://www.bmi-calculator.net/bmr-calculator/harris-benedict-equation/

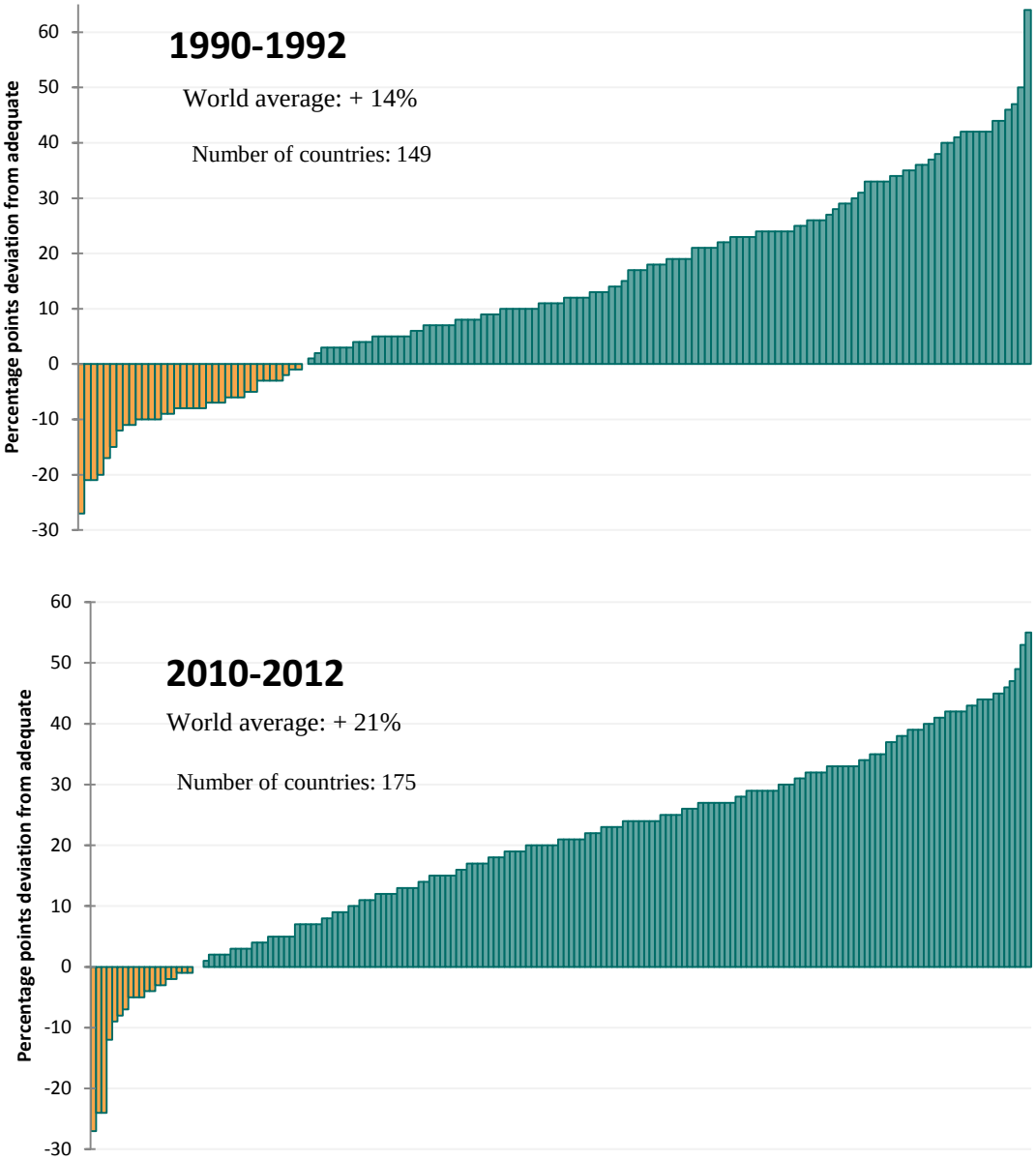
[4] FAO's *Average Dietary Energy Supply Adequacy* indicator for countries gives an average that accounts for differences in sex and age of populations. It expresses national average energy supply (in kcal/cap/day) as a percentage of the Average Dietary Energy Requirement (ADER) for each country, defined as: '… a proper normative reference for adequate nutrition in the population. While it would be mistaken to take the value ADER as the cut-off point to determine the prevalence of undernourishment, its value could be used to calculate the depth of the food deficit (FD), that is the amount of dietary energy that would be needed to ensure that, if properly distributed, hunger would be eliminated.'

FAO uses age-structure estimates of population to calculate ADER, and assumes a moderate activity level.

[5] Most countries (14) were in sub-Saharan Africa (in order of increasing average dietary energy supply) : Burundi, Comoros, Eritrea, Zambia, Namibia, Congo, Swaziland, Botswana, Kenya, Zimbabwe, Ethiopia, Madagascar, Central African Republic, and Tanzania; two were in Asia: Democratic People's Republic of Korea and Timor Leste; two in the Middle-East: Occupied Palestinian Territories and Yemen; and one in the Caribbean: Haiti.

1992, the earliest date at which this statistic is reported, when 35 of 149 countries had below 100% of their estimated energy requirements (Figure 2.1).

Figure 2.1 Average dietary energy supply, percentage of estimated need, 1990-1992 and 2010-2012



Source: FAO food security statistics.

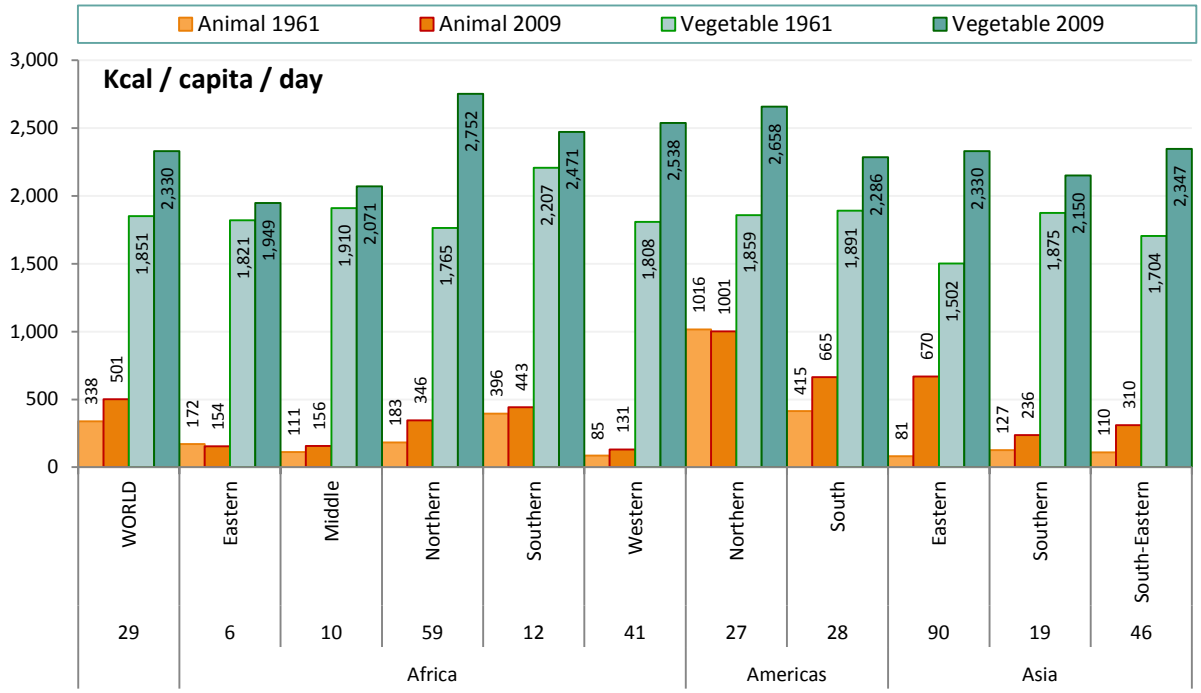
Note: 0 = 100% adequate; <0 = inadequate; >0 = more than adequate (by the FAO estimated measure for national supply).

Trends in proportion of calories from animal and vegetable sources

Globally, the average dietary energy available has increased from 2,190 kilocalories per capita, per day (kcal/cap/day) in 1961 to 2,830 kcal/cap/day in 2009, an increase of 29%. Calories from animal sources contributed a growing proportion of this energy, rising from 340 to 500 kcal/cap/day, an increase of 48%; while there was a lower increase in energy from vegetable sources: from 1,850 to 2,330 kcal/cap/day (26%).

Changes in food energy supply over the past five decades differ significantly by region, see Figure 2.2 (Appendix 1 shows the regional breakdown in more detail). In Eastern Asia for example, and predominantly in China, food energy per capita has shot up by 90%. There have been impressive increases in the consumption of both animal and vegetable foods, with the share of animal foods increasing from 81 to 670 kcal/cap/day and vegetables from 1,502 to 2,330 kcal/cap/day. In Southern Asia by comparison, and predominantly in India, food energy supply increased by only 19% over the same period. Northern and Western Africa showed considerable increases in overall kilocalorie supply with growing consumption of vegetable-source foods accounting for the lion's share of these increases in both regions. Increases have been far more limited in Eastern and Middle Africa. Indeed, kilocalories from animal source foods remain very low across most of the African continent: below 200 kcal/cap/day in Eastern, Middle and Western Africa.[6]

Figure 2.2 Change in energy supplied from animal-sources and vegetable-sources: 1961 to 2009, by region



Source: Data from FAOSTAT.

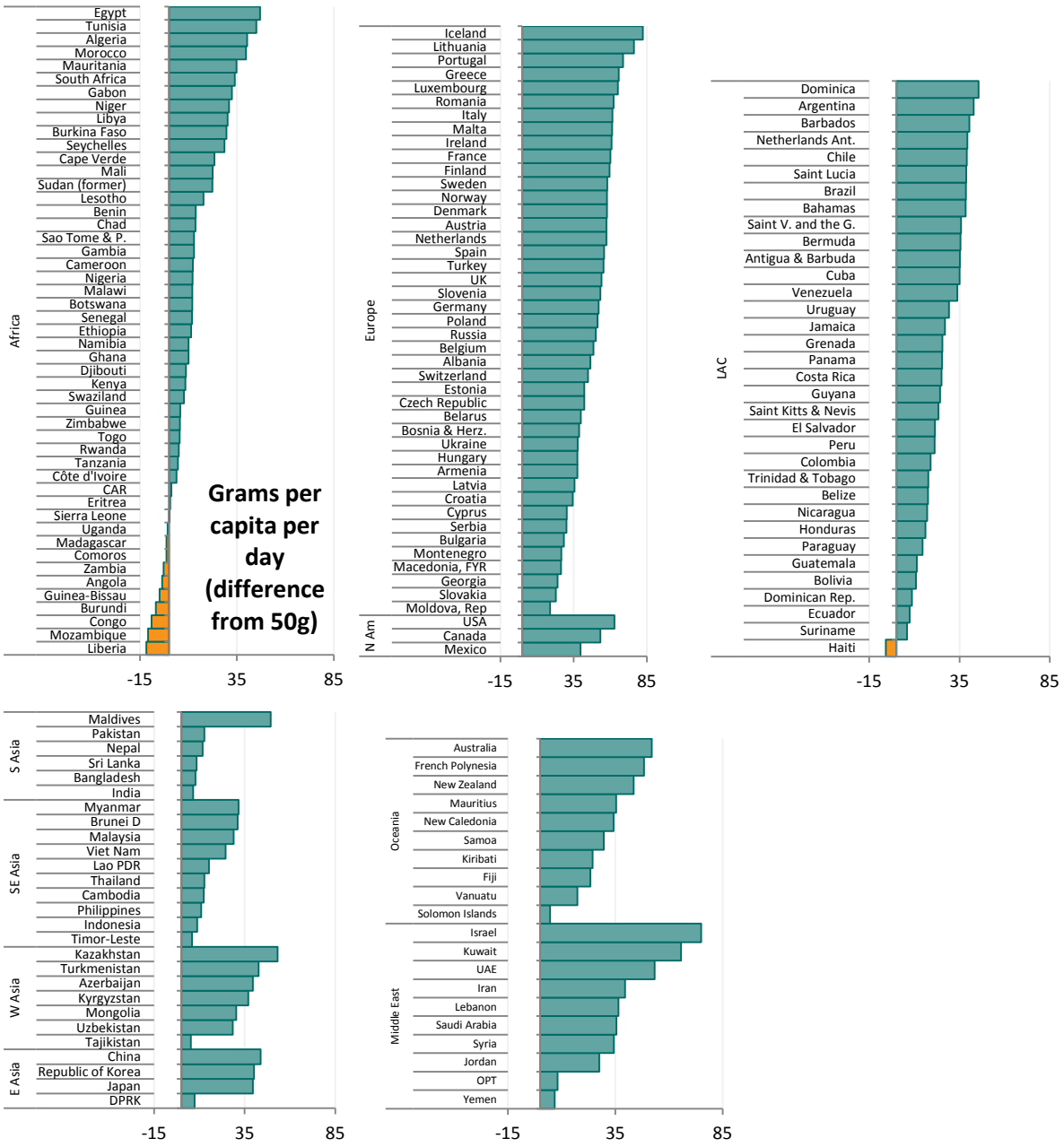
Note: Numbers along the horizontal axis represent percentage increases in total kcal/cap/day available from 1961 to 2009. Regional breakdowns follow the FAO regional definitions, available at http://faostat.fao.org/site/371/default.aspx

Protein supplies

Taking all countries together, the average protein supply in 2009 was 79 grams a person a day: an adequate supply overall, given that an average and moderately active adult requires around 50 grams each day (CDC, 2012). On average, very few of the 176 countries – Liberia, Mozambique, Congo, Burundi, Haiti, Guinea-Bissau, Angola, Zambia, Comoros, Madagascar, and Uganda (in ascending order of protein intake) – have average protein intake below 50g/cap/day (Figure 2.3).

[6] The regions named here and throughout the report are official FAO (UN) designations.

Figure 2.3 Protein supply, grams/cap/day, difference from 50g/cap/day, 2009



Source: FAOSTAT

Changing patterns of food consumption

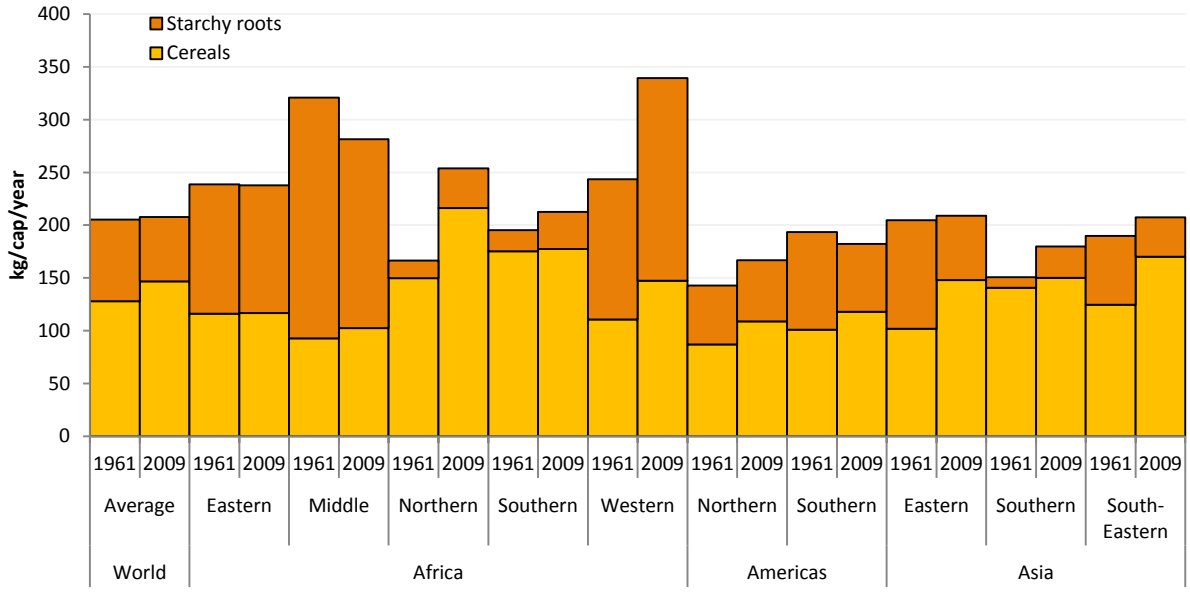
The general pattern shows large increases in the consumption of animal produce, fat and sugar, modest increases in the consumption of cereals and other starchy staples as well as fruit and vegetables, and a decline in the consumption of pulses.

Cereals and starchy staples

From 1961 to 2009, global cereal consumption per head increased from 128 kg/cap/year to 147 kg/cap/year – an increase of 19 kg/cap/year, or about 15%. Over the same time, the consumption of starchy roots fell, from about 77 kg/cap/year to 61kg/cap/year – a decrease of 17 kg/cap/year, or around 21%. On balance, the combined consumption per head of cereals and starchy roots increased by only about 1% (Figure 2.4). Dietary energy increased, however: given that cereals tend to be more

than twice as rich in energy as any of the starchy roots, this implies a net dietary energy gain of 8% or more.[7]

Figure 2.4 Supply of cereals and starchy roots, by region, 1961 and 2009

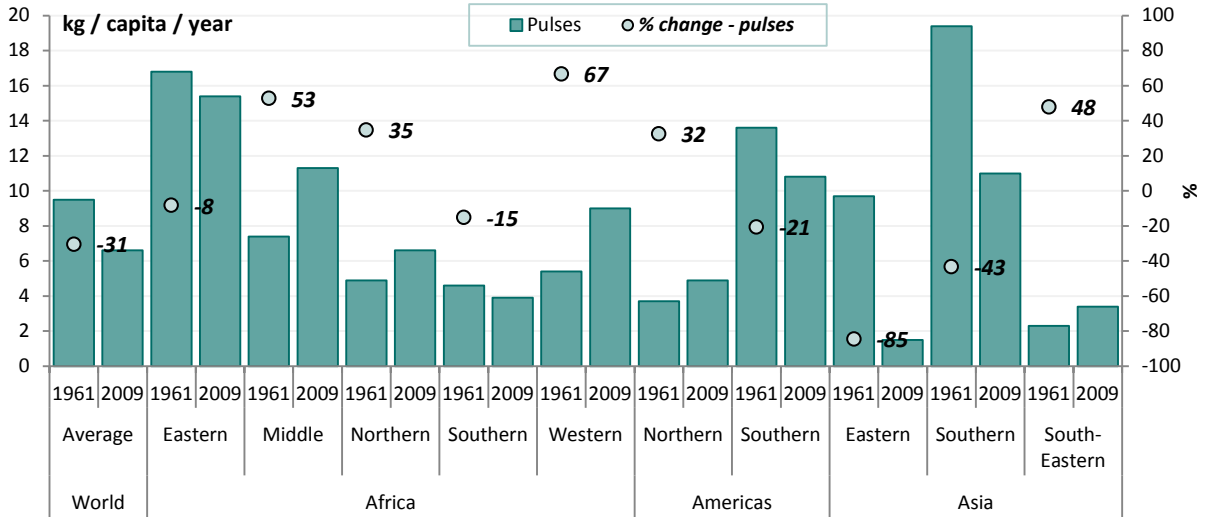


Source: FAOSTAT.

Pulses

Consumption of pulses per person has tended to fall over the past five decades (Figure 2.5), decreasing by almost one third from 1961 to 2009, with much of this decrease occurring in Eastern and Southern Asia. In this region, as elsewhere, pulses have been partly replaced in diets by animal products as people have become wealthier.

Figure 2.5 Supply of pulses, by region, 1961 to 2009



Source: FAOSTAT.

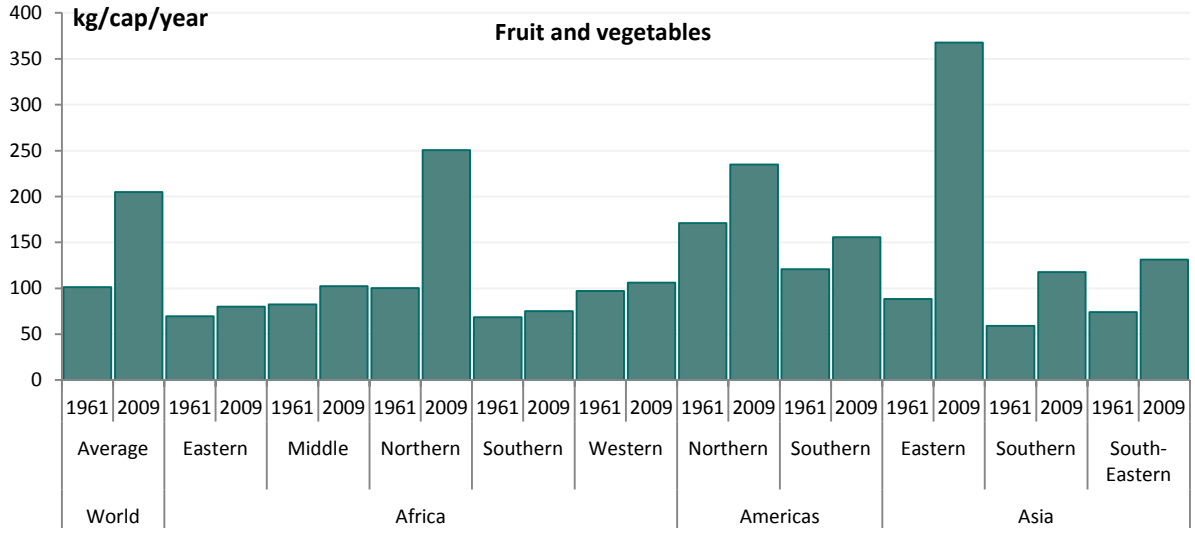
[7] Typically, cereals contain 3,500 kcal/kg; cassava can yield as much as 1,500 kcal/kg, with less kcal/kg for potatoes.

Fruit and vegetables

The WHO recommends that people eat 400 grams of fruit and vegetables, excluding starchy roots, each day (146 kg/year) on average, though some think the recommendation should be higher: at least 600 grams a day (219 kg/year).[8]

Globally, the supply of fruits and vegetables per person doubled between 1961 and 2009, rising from 101 to 205 kg/cap/year. Eastern Asia (dominated by China) saw the most impressive growth, with a 316% increase in the supply of fruit and vegetables supply over that period (Figure 2.6).

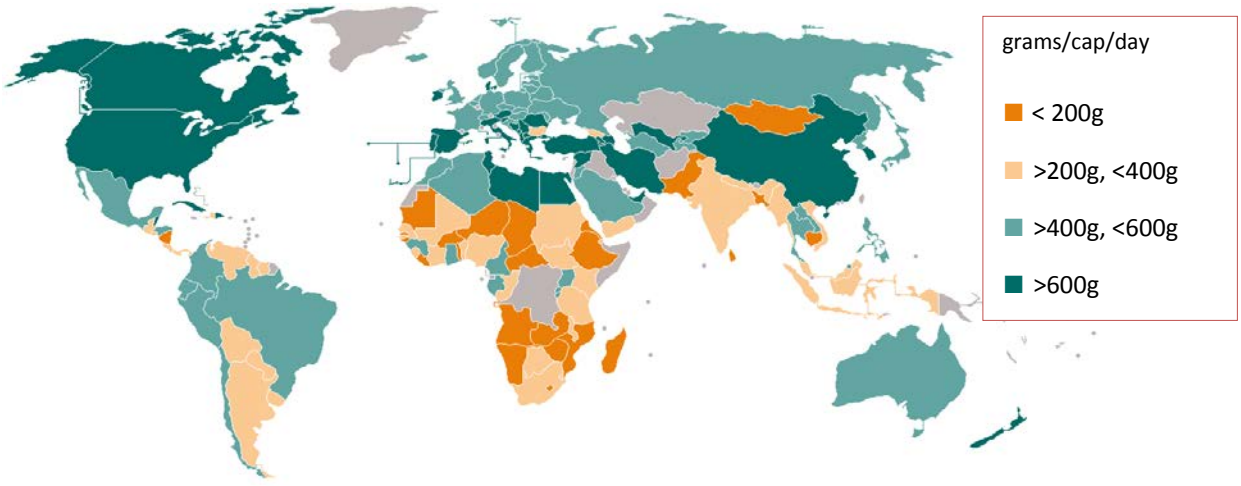
Figure 2.6 Fruit and vegetable supply globally and in selected regions, 1961 and 2009



Source: FAOSTAT.

Note: Appendix 3 provides more regional detail.

Figure 2.7 Fruit and vegetable supply per capita, 2009



Source: FAOSTAT. Map from Wikimedia commons.

Note: FAO database contains small island states not visible at this resolution.

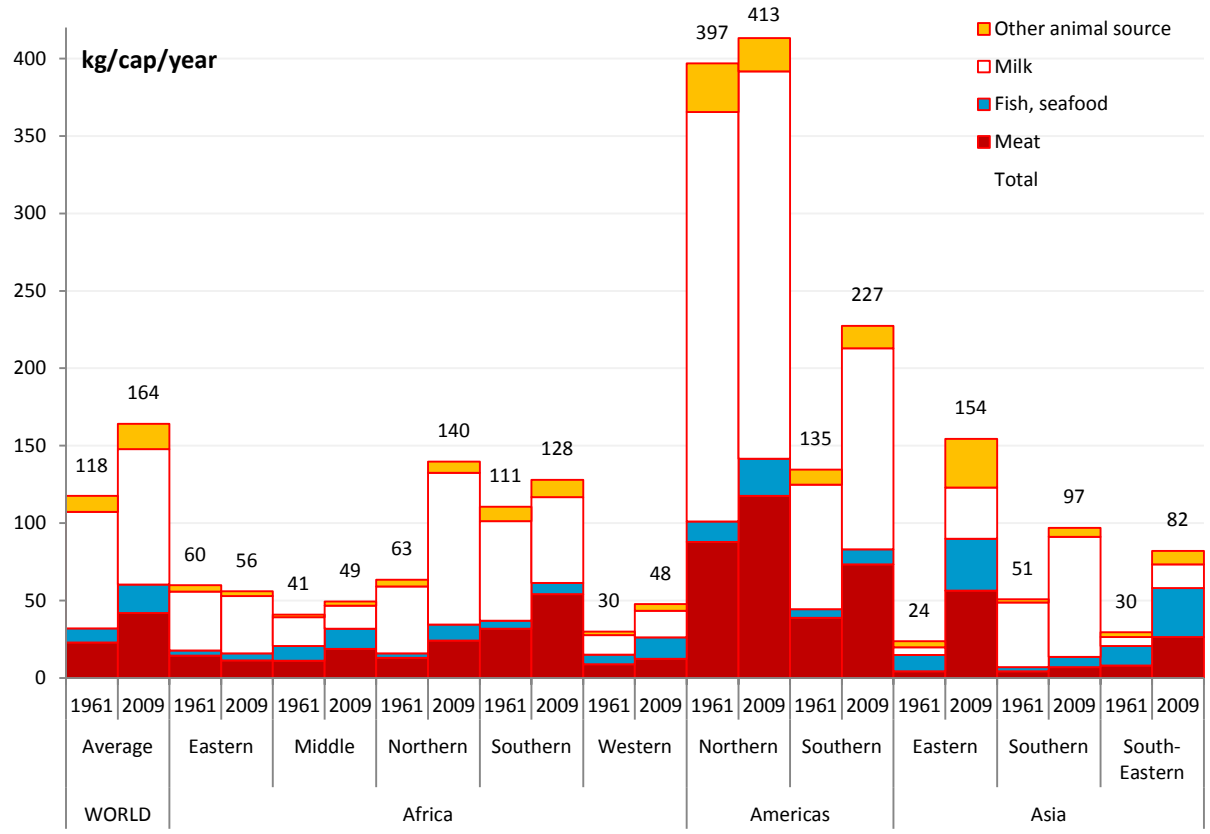
[8] Lock et al. (2005) estimated the global burden of disease resulting from low consumption of fruit and vegetables using a baseline of 600g per capita per day.

Considerable differences can be seen in fruit and vegetable consumption across the world (Figure 2.7). Of the 176 countries in the FAO database, 25 (14%) achieved less than half the WHO-recommended levels, 47 (27%) had more than half but still less than the WHO-recommended levels; 60 (34%) reached the WHO-recommended levels but did not reach the alternative 600 g/day level. Only 44 countries, or 25% of those in the database, had per-capita daily supply above the 600 g/day threshold.

Animal-source foods

Animal-source foods are not only a source of protein, but also contain some vitamins and minerals in concentration that are relatively easy to absorb.[9] The global supply of animal-source food available rose on average from 118 kg/cap in 1961 to 164 kg/cap in 2009, a 40% rise (see Figure 2.8, and see Appendix 2 for regional details). Most of this increase came from meat (mainly poultry, pork and beef), the consumption of which soared by 19 kg/cap/year, from 23 kg/cap/year in 1961 to 42 kg/cap/year in 2009, a rise of 82%. Fish and seafood consumption increased by about 10 kg/cap/year, from 9 kg/cap/year in 1961 to 19 kg/cap/year in 2009. Milk consumption increased from about 75 kg/cap/year in 1961 to 87 kg/cap/year, an increase of 12 kg/cap/year.

Figure 2.8 Animal food by type and by region, 1961 to 2009



Source: FAOSTAT.

Note: Figures for Northern America are dominated by the United States while those for Eastern Asia and Southern Asia are dominated by China and India.

Total animal-source foods includes those not covered by the three categories shown, including eggs and offal.

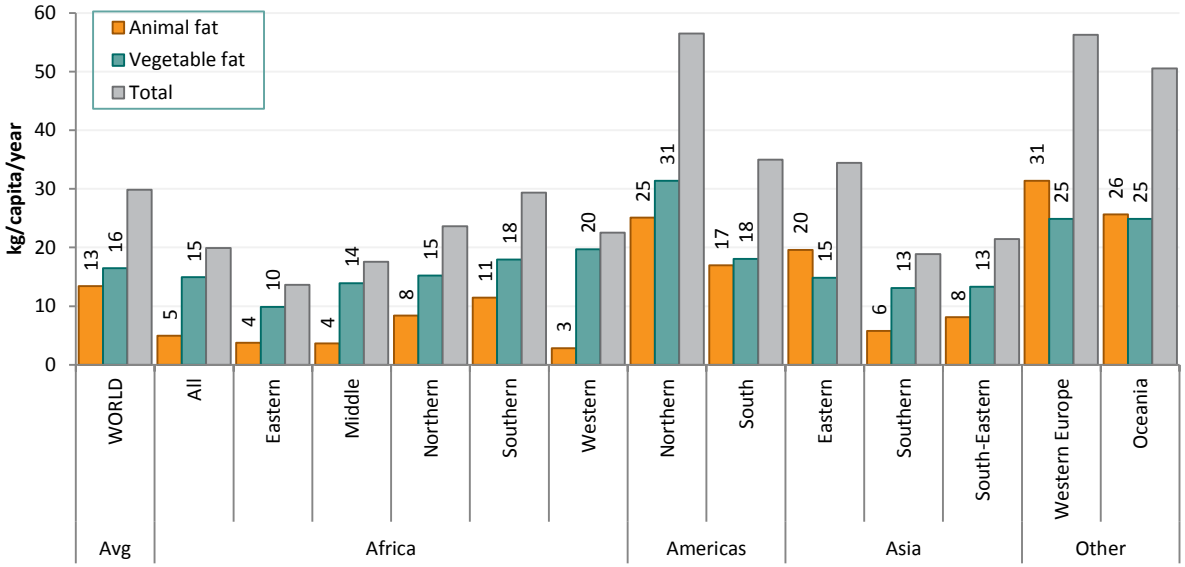
[9] Dietary iron, for example, comes in two forms: heme, found in animal tissues, and non-heme, found in plant sources. Non-heme iron is absorbed less efficiently than heme iron in human digestion (Ohio State University, 2004). Eating meat with non-heme iron can also aid its absorption (Neumann et al., 2002).

The availability of animal-source foods increased almost everywhere between 1961 and 2009. Eastern Asia saw the most impressive increases overall, while Southern Asia and North Africa increased milk supply by notable amounts, and the fish and seafood increases seen in South-Eastern Asia were remarkable. In contrast, increases in supply in Eastern Africa failed to match population growth, while increases in Middle, Southern and Western Africa were limited.

Fats

The average global supply of fats per person in 2009 was about 82 grams a day, 30 kg/cap/year (Figure 2.9).[10] Industrialised countries now have much higher (often more than double) the levels of fat supply seen in developing countries. Within the developing world, fat consumption is now highest in East Asia and Southern Africa.

Figure 2.9 Fat supply from animal and vegetable sources, by regions, 2009

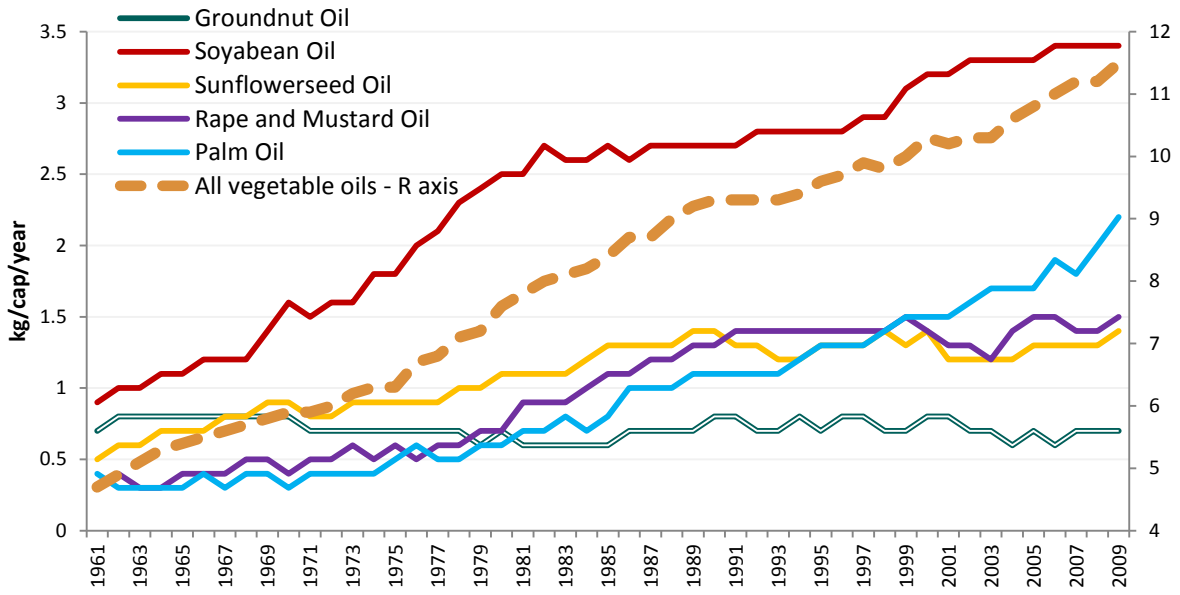


Source: FAOSTAT.

Worldwide, a little more fat comes from plants than animals. The share from plants tends to dominate in the developing world in general, and in Africa in particular. In West Africa, for example, seven times more fat comes from vegetables than from animals. Most of the increase in fat consumption seen in the developing world over the past 50 years has come from vegetable oils. Worldwide, vegetable oil availability increased by 130% per capita from 1961-1963 to 2007-2009, with large increases seen in soybean and palm oil (Figure 2.10).

[10] More details and trends from 1961 to 2009 are available in Appendix 6.

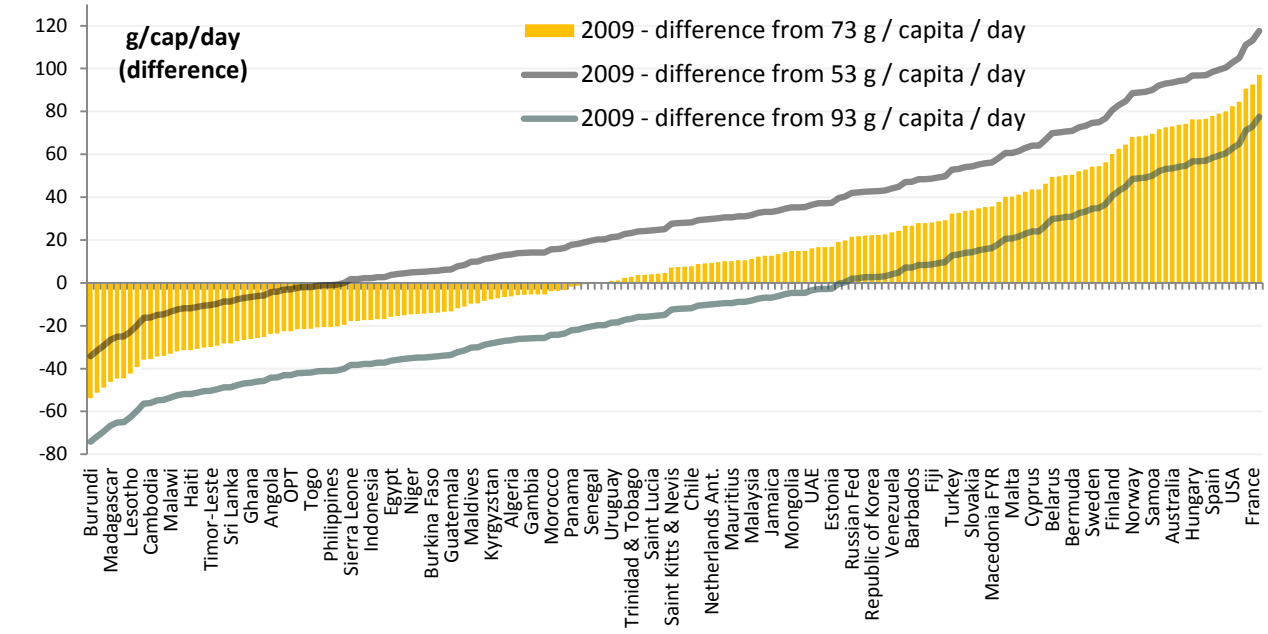
Figure 1: Figure 2.10 Supply of vegetable oils, kg/cap/year, 1961 to 2009



Source: FAOSTAT.

Do countries then have enough fat or too little? USDA (1996) recommends 53-93 g/cap/day depending on overall calorie intake. Taking the mid-range estimate of 73 g/cap/day, 100 countries were above this level of fat in 2009, with only 76 below it (Figure 2.11). Fat consumption correlates strongly with income (Figure 2.12), with almost all OECD countries showing fat consumption above the highest recommended levels, while most of the countries with low levels (where diets may be deficient in fats) are low-income.

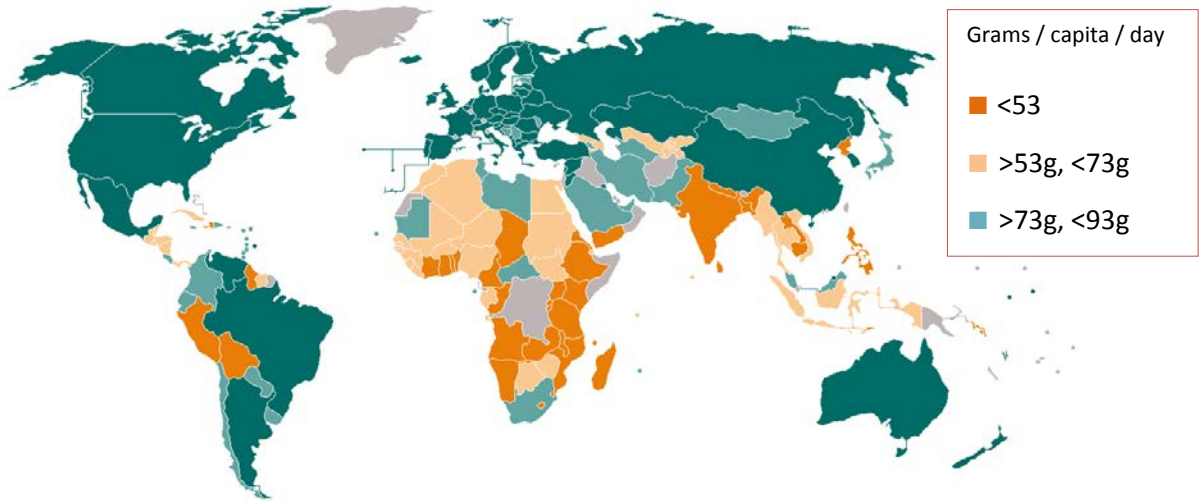
Figure 2.11 Fat supply per capita compared to recommended levels in 176 countries, 2009



Source: FAOSTAT.

Note: Labels on the horizontal axis are examples – not every country is listed.

Figure 2.12 Fat supply per capita per day, 2009

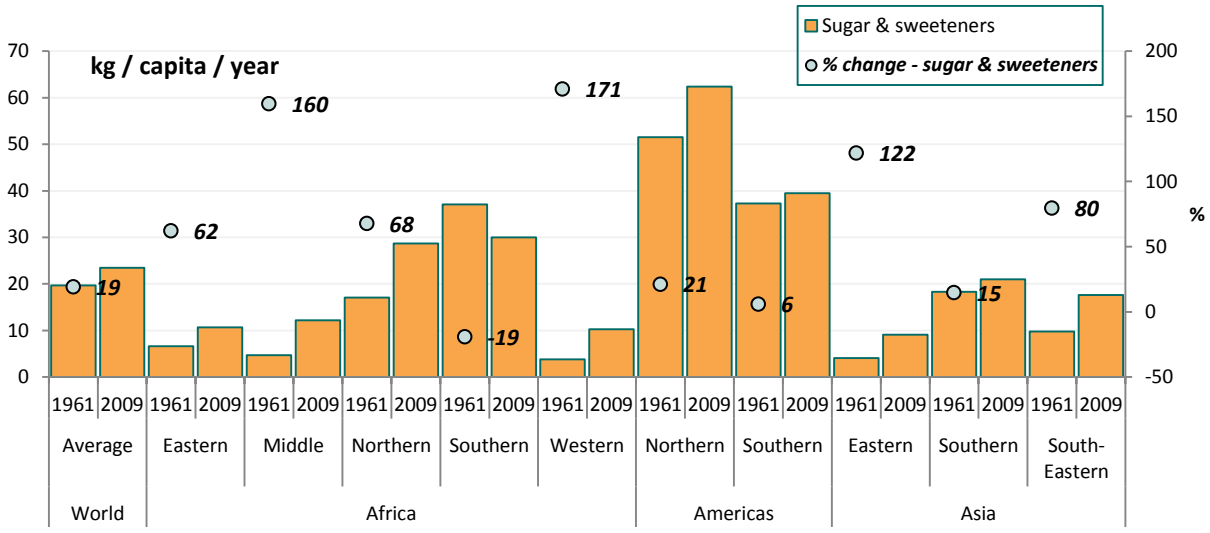


Source: FAOSTAT. Map from Wikimedia commons.

Sugar and other sweeteners

Between 1961 and 2009, sugar and sweetener food supply grew by about one fifth per person (Figure 2.13). Of the selected regions shown, the growth in the overall availability of sugar and sweeteners, as well as its change over the 50-year period, has been most evident for Northern America (Canada, Mexico and the US).

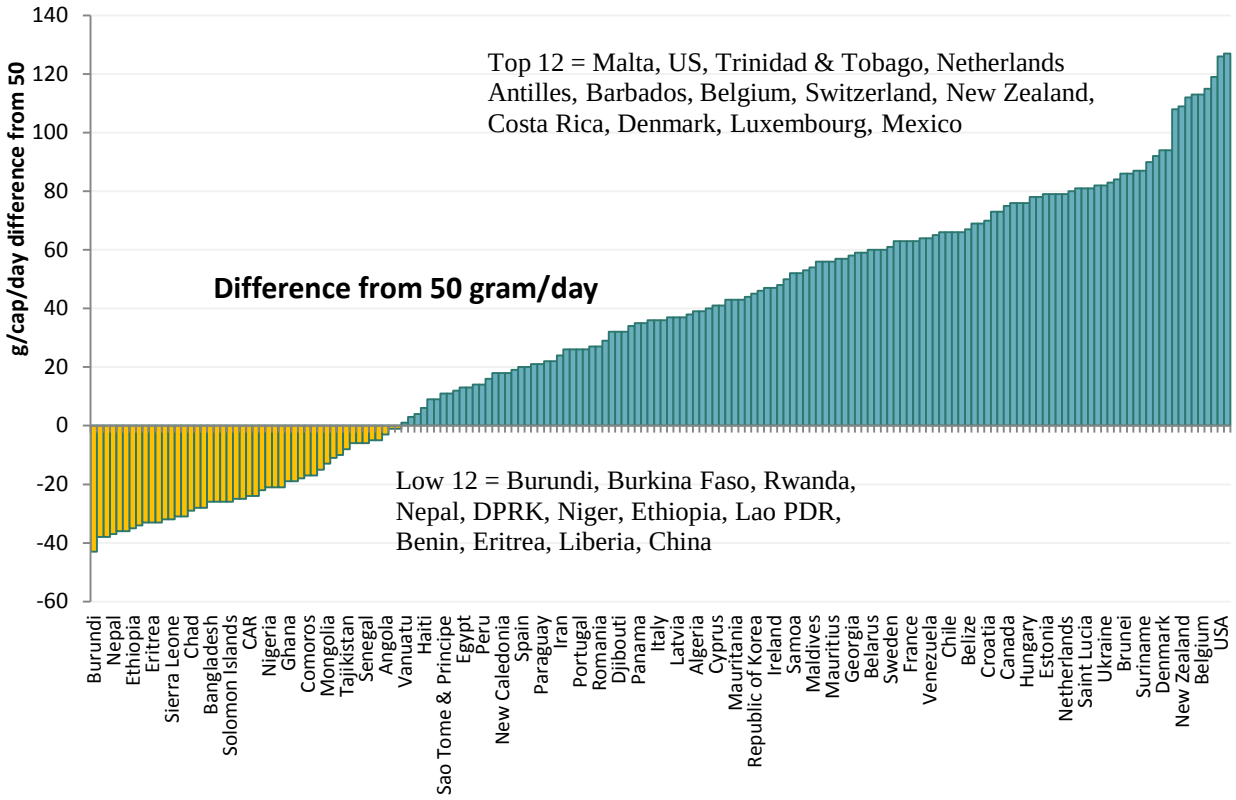
Figure 2.13 Sugar and sweeteners, by region, 1961 to 2009



Source: FAOSTAT.

How does this level of sugar consumption compare to recommended levels? The recommendation is that the average adult should not consume more than 60 grams[11] of sugar and caloric sweetener[12] each day. Figure 2.14 shows how national per capita sugar consumption differs from 50 g/cap/day – a little below the adult recommendation to reflect children's lower needs – for all countries in 2009. For most countries, sugar supply was above recommended levels, with only 48 countries out of 176 having per capita sugar supply below 50 g/cap/day. No fewer than 69 countries had sugar consumption that were more than double the recommended maximum level.

Figure 2.14 Daily per capita sugar consumption, 176 countries, 2009, difference from 50 grams



Source: FAOSTAT.

Note: Labels on the horizontal axis are examples – not every country is listed.

Dietary differences in selected middle-income countries

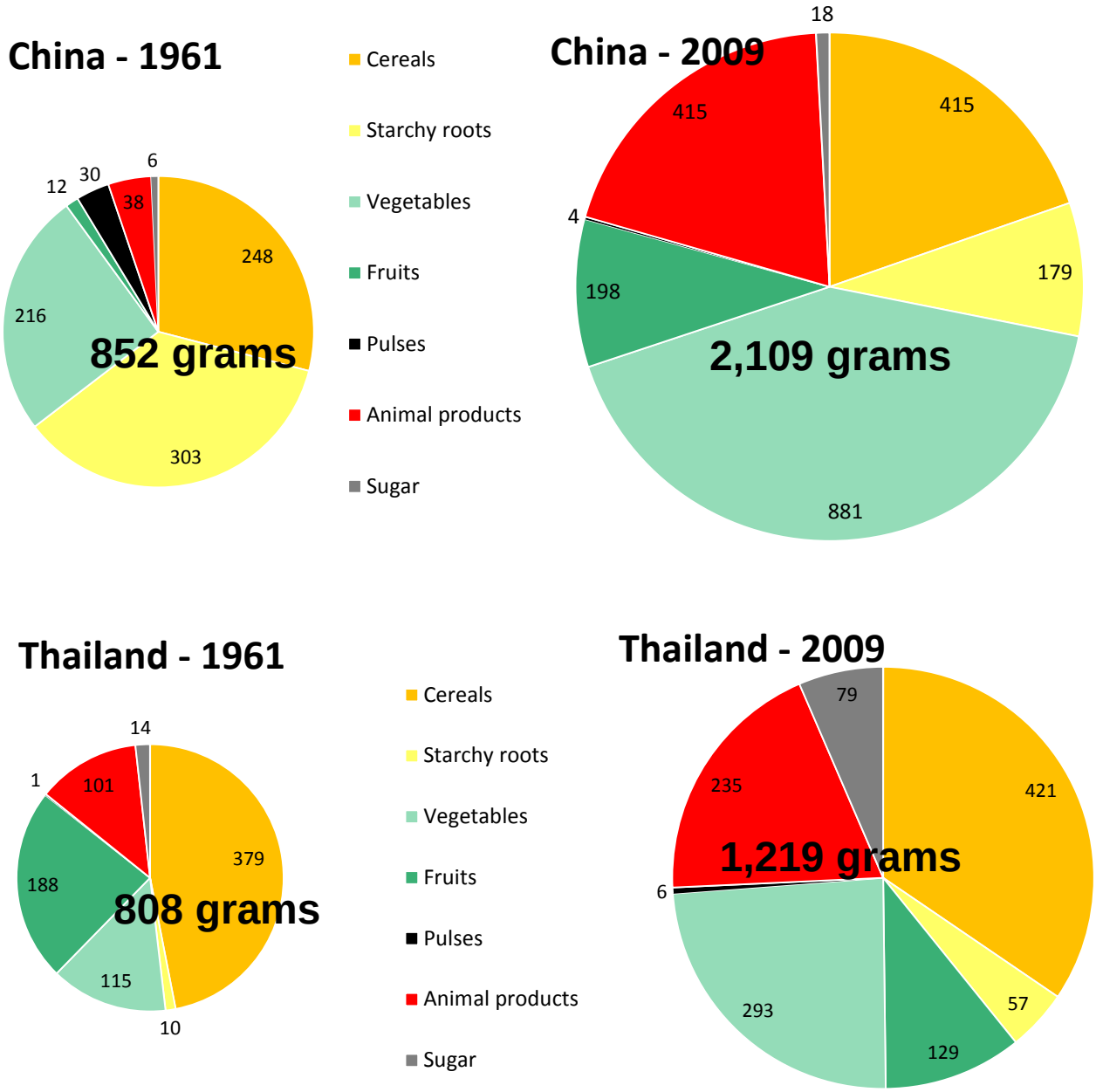
A comparison of average diets across our selection of five case-study countries – China, Egypt, India, Peru and Thailand – shows differences in diets and their evolution across middle-income countries (Figure 2.15) and a variation in the consumption of animal products across these countries (Figure 2.16).

[11] See, for example, the recommendations by the UK National Health Service, which say an average man should not exceed 70g and an average woman 50g of sugar a day (these are not recommended levels but rather maximum thresholds) As the FAO database includes children, the rate of 50g was chosen for the baseline.

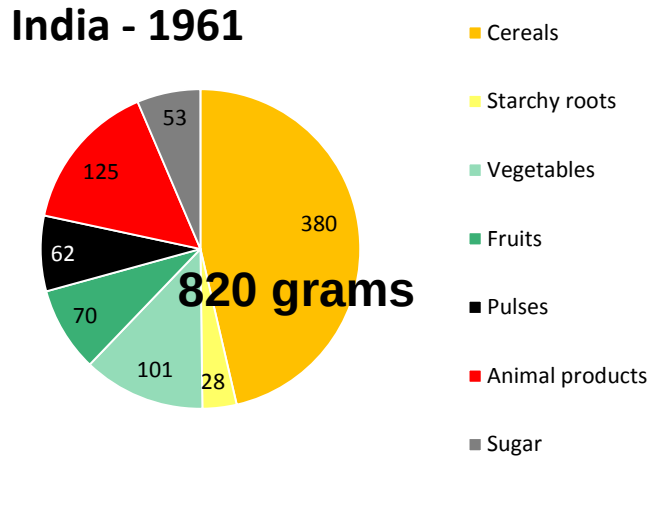
[12] This includes other sweeteners such as corn syrup, much used in food processing.

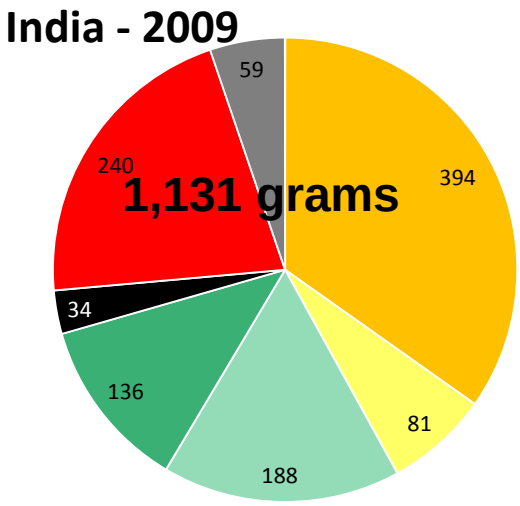
Figure 2.15 Food plates for China, Thailand, India, Egypt, and Peru, g/cap/day, 1961 and 2009

Eastern Asia

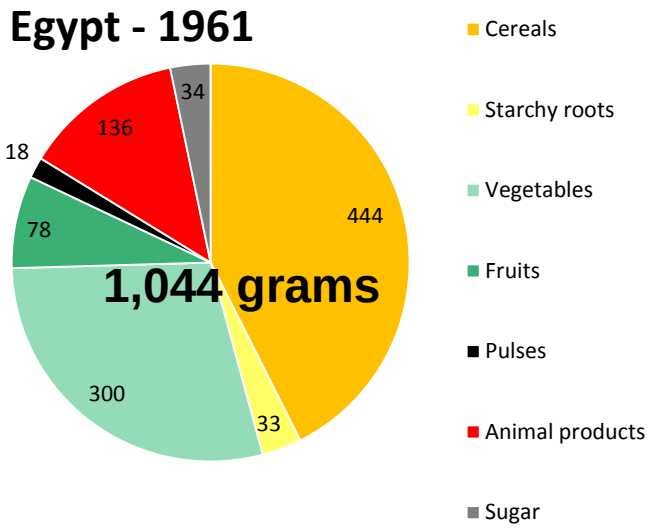


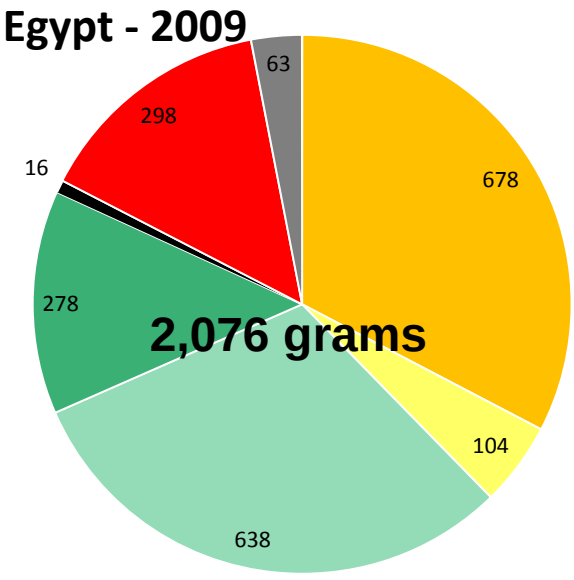
Southern Asia



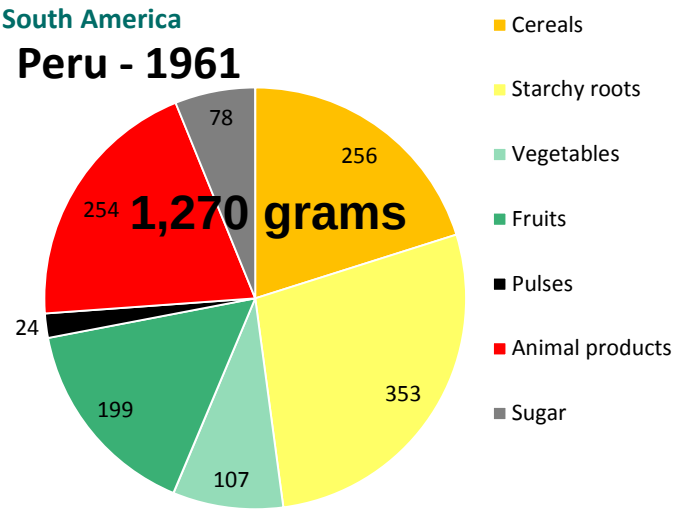


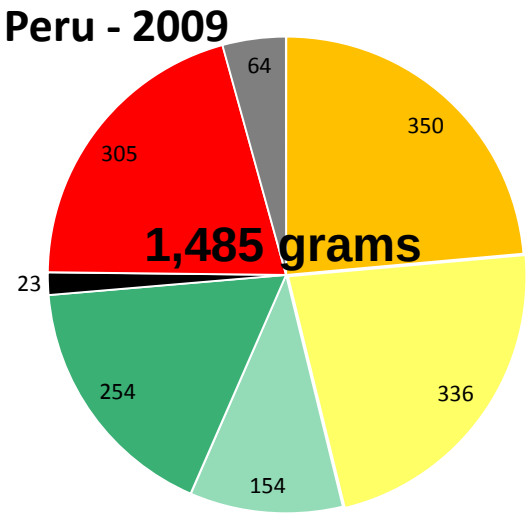
Northern Africa





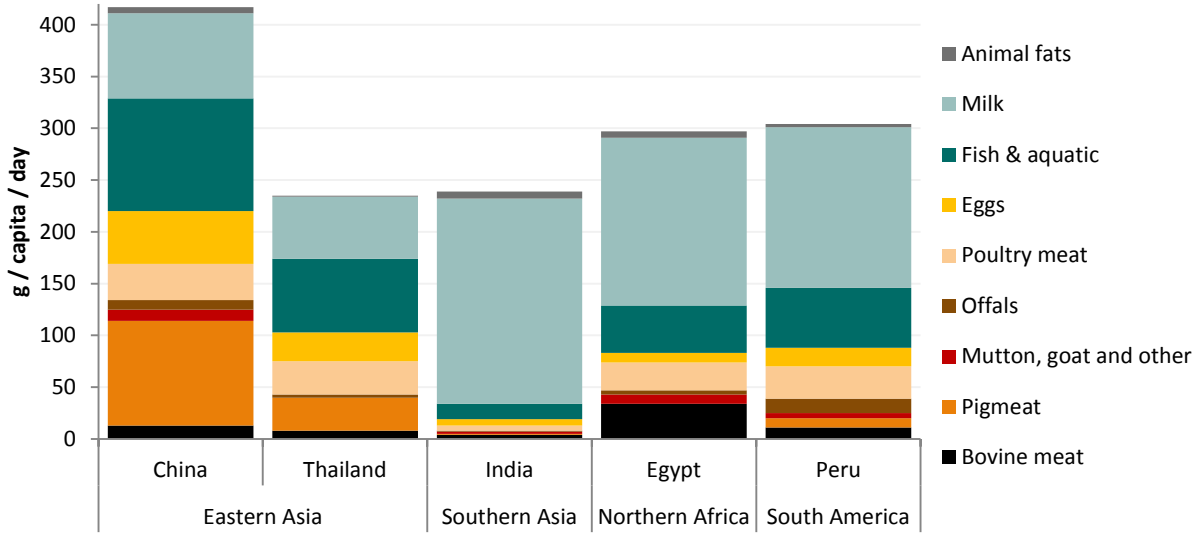
South America





Source: FAOSTAT.

Figure 2.16 Animal source foods in case study countries, 2009



Source: FAOSTAT.

In ***China***, the first of our Eastern Asia case-study countries, increasing incomes have meant more consumption of all food groups except for pulses and starchy roots. Proportionally, diets are now richer in animal products and vegetables than they were in the 1960s. Vegetables and fruits take up slightly more than half the plate. Sugar consumption, however, is low.

In contrast, the per-head consumption of starchy roots and pulses in our second Eastern Asian country – ***Thailand*** – has gone up. While vegetable consumption barely increased between 1961 and 2009, fruit consumption grew a great deal. Thais now consume more fruit than their counterparts in the other case study countries; even consuming more fruit than animal products.

In Southern Asia, ***India's*** consumption of animal products is approaching that of China's in terms of its contribution to the average plate, but here the increase is almost entirely in milk consumption, with only limited increases for meat. Many Indians are vegetarian, avoiding beef or pork for cultural and religious reasons. The consumption of pulses remains relatively high in India, although it has been on the decline.

In South America, ***Peru*** is notable for the lack of change in the proportions of different foods in the diet over the past 50 years. For example, while consumption of pulses is declining across much of the world, it has stayed relatively steady and high in Peru. The consumption of starchy roots has also remained stable – perhaps a reflection of Peru's long history of potato cultivation.

In Northern Africa, ***Egypt*** shows considerable consumption of fruit and vegetables, as well as fish and seafood. As a result, it seems to belong to the group of Mediterranean countries where traditional diets are heavy in vegetables, seafood, and olive oil (da Silva et al., 2009).

The geographical variation in people's diets is striking, as are differences in trajectories of diets over the past 50 years. It suggests that it is not only income that plays a key role, but also cultural and geographic differences.

Recommended diets compared with actual diets

Increasingly, countries are adopting dietary guidelines to encourage their citizens to consume healthy diets, that is, diets that are adequate in critical nutrients and that avoid the excess consumption of foods that can lead to risk of disease. Recommendations tend to cluster food into groups and recommend a balance between them, and some are tailored by age and sex. Figure 2.17, for example, shows a recommended food pyramid for teenagers in the Philippines (see more examples in Appendix 5).

Figure 2.17 A food pyramid recommending an average diet for a teenager in the Philippines

Source: Reproduced from the Food and Nutrition Research Institute website: http://www.fnri.dost.gov.ph/index.php?option=com_content&task=view&id=1275&Itemid=162

Most guides recommend a diet based on staples of cereals or starchy roots, combined with high vegetable and fruit consumption, moderate levels of animal and vegetable protein and small amounts of fat, salt and sugar. Many combine diet advice with messages to drink water and be physically active.

The World Health Organization promotes nutritional guidelines (see for example WHO, 1998), though these specify recommended levels of vitamins and minerals instead of weights or servings of food, with some exceptions, such as the recommended 400g of fruit and vegetables other than starchy tubers each day (WHO, 2013). Country recommendations are often based on advice from WHO, but, in contrast, tend to specify the volume or weight of food, reflecting local preferences for particular foods. For example, India's 'food pyramid' and Mexico's 'food plate' have more pulses than the UK's 'food plate' or Canada's 'food rainbow'.

Box 1: Ideal diets?

Is there an ideal diet? WHO recommendations and national guidelines tend to specify bands of consumption within which consumers can choose from a range of foods. This reflects, in part, the fact that ideal diets would vary for each individual. Therefore, for each population, or a group within that population, only a general band can accommodate individual requirements. It also reflects the range of scientific opinion about minimum and maximum levels of advisable consumption.

Specifying an ideal diet, however, has become something of an industry, especially when it comes to diets to control and lose weight.

These diets are formulated normatively, but even among observed diets, some have been picked out as especially beneficial. Perhaps the most well-known is the Mediterranean diet,[13] or the Okinawa diet, both of which are rich in vegetables and fish. Attention has been focused on such diets as a result of their perceived correlation with populations that have unusually long lives and low rates of heart disease, cancer and diabetes.

There is also growing interest in ancient diets, such as the Palaeolithic diet:[14] the diet consumed by hunger-gatherers, before agriculture transformed cereals and tubers into abundant sources of dietary energy. Stone-age people ate diverse diets, high in fibre and protein, and low in salt.

Comparing the global availability of food to the dietary guidelines

How does the global availability of different foods measure up to the recommendations? Overall, there is enough food in the world to meet everyone's need for dietary energy and protein. But is the food that is available of the right quality for a good diet?

Fruits and vegetables are emphasised in healthy eating campaigns in the developed world – an emphasis that has increased as the benefits of eating diets rich in fruits and vegetables have been supported increasingly by the science.[15] Guidelines for the US recommend that half the plate be taken up with fruits and vegetables. In Canada too, the emphasis has shifted from breads and other starchy foods to fruit and vegetables.

[13] A pyramid representing this is depicted at the end of Table A5.1

[14] The difference between modern and hunter-gatherer diets has also been used to explain why it can be difficult for people nowadays to achieve recommended intakes of vitamins and minerals; adding an extra imperative to micronutrient supplementation (Kay Dewey, personal communication).

[15] See Lock et al. (2005) for instance reported:

'The total worldwide mortality currently attributable to inadequate consumption of fruit and vegetables is estimated to be up to 2.635 million deaths per year. Increasing individual fruit and vegetable consumption to up to 600g per day (the baseline of choice) could reduce the total worldwide burden of disease by 1.8%, and reduce the burden of ischaemic heart disease and ischaemic stroke by 31% and 19% respectively. For stomach, oesophageal, lung and colorectal cancer, the potential reductions were 19%, 20%, 12% and 2%, respectively.'

Box 2: Canada's colour-shifting food rainbow

The latest version of Canada's Food Guide, which has taken the shape of a rainbow for over 20 years, was to give fruit and vegetables a more prominent position than grain products.

Figure 2.18 Canada Food Guides, 1992 and 2007

Source: Health Canada.

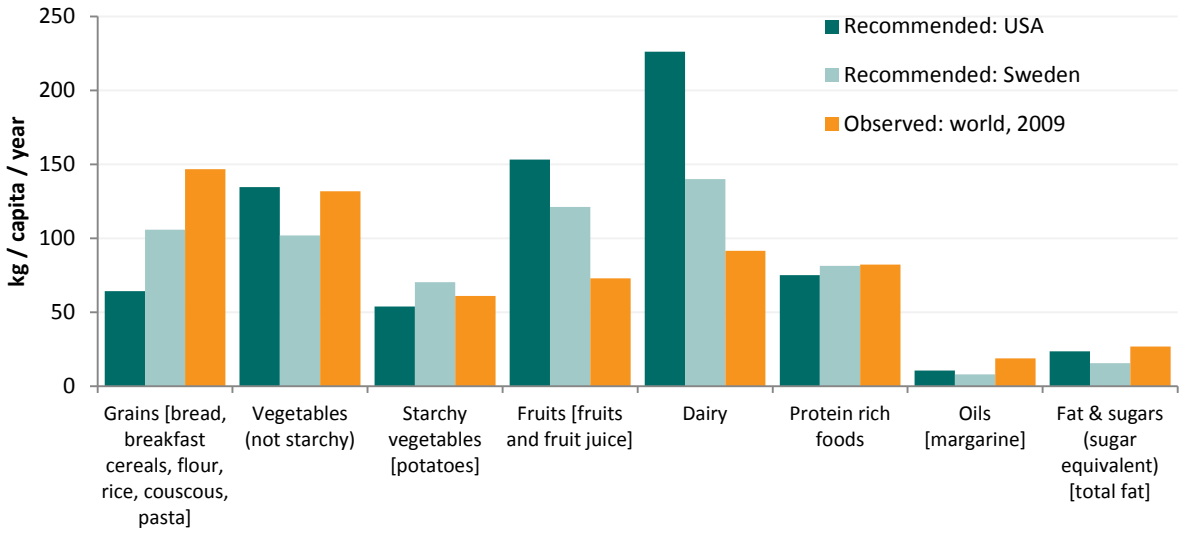
For the first time since the development of Canada's Food Guide, the emphasis has shifted from cereals and starches to vegetables, emphasising the increasing importance given to vegetables in dietary recommendations and recognising people's reluctance to consume a healthy amount of them.

Food-based guidelines for the US (USDA, http://www.choosemyplate.gov/) are among the most detailed available. Using a USDA weekly meal-planner for 2,000 kilocalories per day,[16] it is possible to make a rough calculation of the daily amounts of different food groups recommended in weight terms and compare them to average supply by weight reported by FAOSTAT. US guides are broadly

[16] A 2,000 kilocalorie diet is suitable for average adults who are sedentary (taking little or no exercise) or who are lightly active (light exercise or sports 1 to 3 days a week), older adults, some trying to lose weight and some small children, but is not quite enough for people who are more active [moderately active means moderate exercise or sports 3 to 5 days a week]. This energy intake lies below the Average Dietary Energy Requirement (ADER) estimated by FAO for the world, which was around 2,350 kcal/cap/day for 2007-2013, up from 2,290 kcal/cap/day for 1990-1992.

in line with other national recommendations. Here they are compared to those for Sweden (Swedish National Food Administration recommendations, see Enghardt-Barbieri et al., 2005). The main differences lie in the considerably higher US recommendations for dairy intake, and the higher Swedish recommendations for grains (Figure 2.19).

Figure 2.19 US and Swedish food-based dietary recommendations in weight compared with global supply averages for 2009



Sources: Data from USDA, Enghardt-Barbieri et al. (2005) and FAOSTAT.

Note: More detail on US guidelines can be found in the note to Figure 2.19.

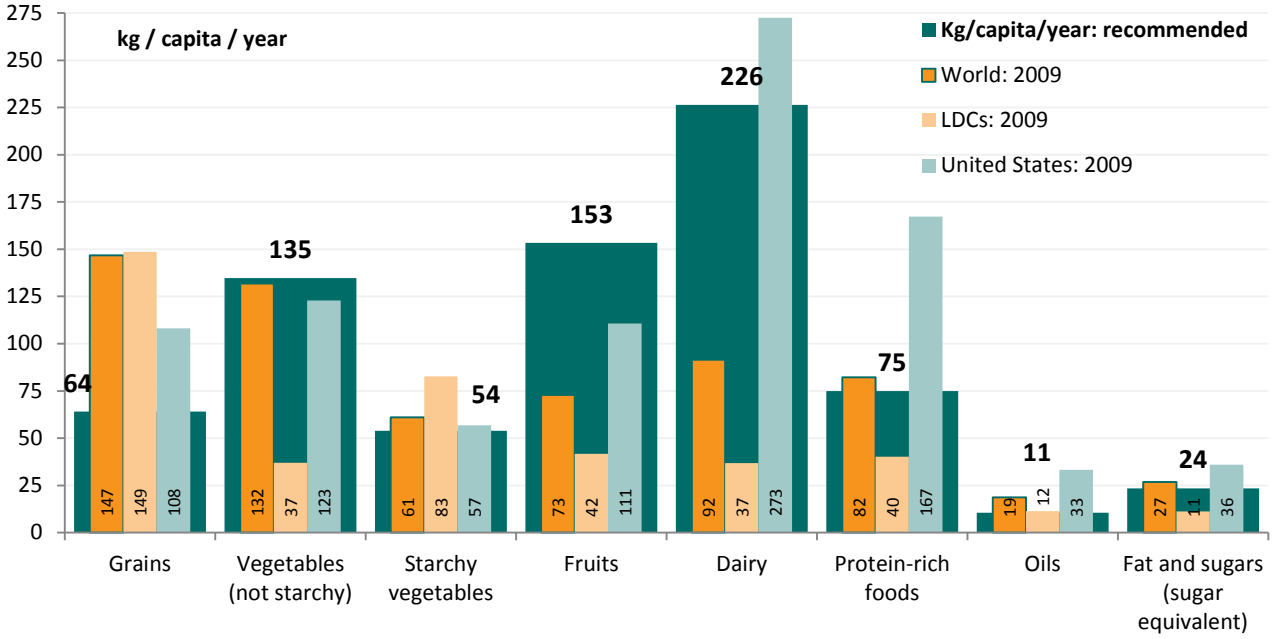
Swedish Guidelines are taken as an average of those recommended for an adult man and woman of working age with little to moderate physical activity, and with 'Swedish' eating habits. Labels in square brackets represent the slight divergence of Swedish food groups from those of USDA (not in bracketed or in round brackets).

Looking at the average world intake of foods compared to both sets of guides, as shown in Figure 2.19, the strongest differences can be seen between an over-supply of grains, oils and fats and sugars and a notable under-supply of fruit and dairy.

Supply in the US does not, on average, tally with government recommendations either. The volume supplied outstrips the volume required by some two-thirds in the case of grains, and by half for both fats and sugar, while the volume of protein supplied is more than twice as high as the amount actually required. Similarly, the amount of oil supplied is three times as high as the amount needed, while dairy supply exceeds need by one-fifth. Fruit supply, on the other hand, stands at less than three quarters of the required amount. Only vegetables and starchy vegetables, at about 91% and 113% of requirements respectively, come close to the recommended levels.

This imbalance between supply and need is even worse for LDCs. Only grains and starchy vegetables show an excess in supply, at 233% and 154% of recommended levels respectively, while the supply of oils is sufficient. The supply of both fruit and vegetables amounts to less than one third (30%) of what is required, while the supply of protein, fats and sugars amounts to around half of the amount needed. The supply of dairy would meet only around one sixth (16%) of the need.

Figure 2.20 US government recommended levels compared with the supply of food groups for the world, least-developed countries and the US

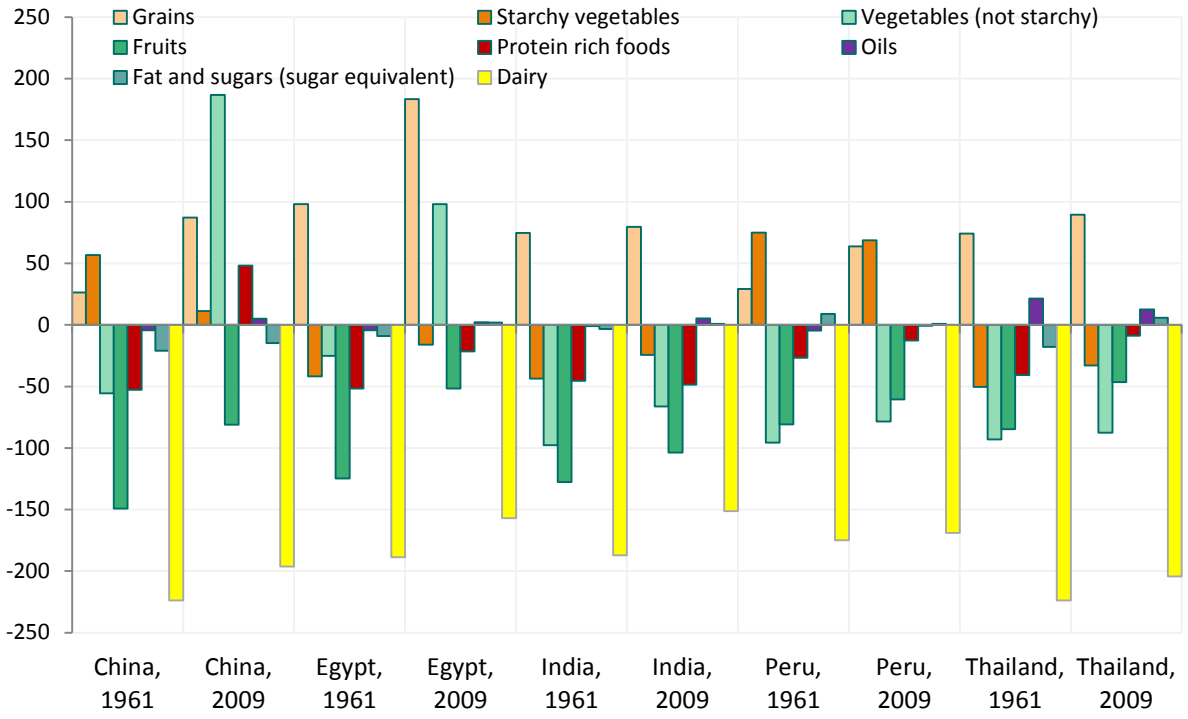


Source: Food supply data from FAO (estimates of product available for food use, not including feed and other uses) and recommended dietary guidelines from the US Government.

Note: According to the recommendations taken from the US Government (http://www.choosemyplate.gov/): protein-rich foods required in the guidelines vary between 5.7 and 8.8 oz per person/day, so an average is shown above. The fruit and vegetable requirements shown result from an estimate whereby 1 cup = 200 grams (this will vary fairly dramatically depending on the type and preparation of the fruits and vegetables). The recommended levels are estimated for an average adult. The amount of dairy required is drawn from an estimate whereby 1 cup = 180 grams (while a cup of milk weighs about 250g, a cup of grated cheese will weigh much less).

Figure 2.20 shows the variations between national average consumption and the US recommendations for the selected middle-income countries. Two things are apparent. First, the deficits evident in 1961 are less so in 2009 across just about every country and food group. Second, there are recurring country-level patterns of over-supply of grains and in some cases starchy vegetables, while significant deficits persist for dairy, fruit and vegetables.

Figure 2.21 Food-group supply in middle-income case-study countries compared with US dietary recommendations, 1961 and 2009 (% of US recommended amounts)



Source: Data from USDA and FAOSTAT. Note: For a description of USDA recommendations, see the note to Figure 2.16.

In sum, then, these comparisons between the average diets and the diets that are recommended show that diets across the world tend to have more than enough grains, but are low in dairy and fruit. In high-income countries, such as the US, consumption of oil, fat and sugar are well above the recommended levels. At the other end of the scale, LDCs have average diets that are very short of fruit, vegetables, dairy and protein-rich foods.

Influences on diets

The statistics we have reviewed so far deal in national averages. But further variation exists by economic and social groups, by regions within countries, and by individual preferences. Influences on national, local and individual diets can be clustered in the following five sets of factors (Kearney, 2010; Mazzocchi et al., 2012):

- biological factors that vary amongst individuals by age, gender, activity levels and health
- economic access to food: the affordability of different foods that stems partly from their prices and partly from incomes
- individual preferences and the factors behind them, including custom, religion, and beliefs about foods
- social changes in work and gender roles
- globalisation in the form of liberalised trade, investment and information flows

- government policy through, for example, information provision, subsidies, taxes, or price policies.

Biological factors

The most basic influence on diet is the physiological need for energy, protein, vitamins and minerals to allow children to grow and adults to function. Above all, people need to satisfy their need for energy and hunger provides a powerful reminder to alert them when more energy is needed. These needs vary by age, gender, activity levels and health.

They may also vary by genetic adaptation, such as the ability to absorb lactose amongst adults, which may explain the very great variations seen across the world in milk and dairy consumption. High milk consumption can be seen in parts of Northern and Western Europe, and in those parts of the New World to which Europeans migrated in the last 200 years, while the consumption of milk is very low in Southeast Asia. It is now thought that the differences may be physiological, as when cattle-herding peoples spread across Europe 7,000 years or more ago, genetic selection favoured those with genes that could tolerate lactose intake beyond childhood (Curry, 2013).

Some see longstanding needs that have been forged during human evolution as driving modern diets. Evolution certainly favoured people who accumulated fat when food was plentiful and who were, therefore, better able to survive lean times. We may, as a result, have instincts to consume food to excess when possible (Freudenberg, 2010). Indeed, the preference for high-fat foods has been described as a 'universal human trait' (Drewnowski, 1997).

Going one step further, it has been suggested that some foods, especially those dense in energy such as sugars and fats, may be physically addictive (Corsica and Pelchat, 2010).

Others question these views, and attribute contemporary over-eating in affluent societies to circumstances, such as more sedentary lives and an environment where energy-dense foods are easily available and cheap. Freudenberg (2010), for example, declares that obesity:

> *'… does not result from changes under the skin, but rather from alterations of the environment in which people decide what to eat and how much to move.'*

Economic access to food: affordability

What people eat depends, in large part, on what is available and what they can afford – a function of the cost of food and incomes.

The ***cost of food*** has been falling in most parts of the world for most of the past 150 years or longer. For example, in the US in the 1870s, wheat cost between $600 and $800 a tonne in real terms, using prices for 1999. By 1999 that price had fallen to less than $100 a tonne (USDA data, deflated by the US consumer-price index). There was a particularly sharp fall in the costs of growing basic foods in the second half of the twentieth century as farmers took advantage of technical advances in farming and relatively cheap fuel and fertiliser to expand food production ahead of population growth. By 2001, the price of maize on world markets was just 25% of the price in 1957 in constant terms, while the prices for wheat and rice were 25% and 31% respectively of the 1957 price.

It is not just unit costs of production on farms that have fallen. Advances in transport and storage, particularly in refrigeration, have cut the costs of getting food from the farm to the consumer, as well as expanding the range of food on offer through the year and the geographical source of the food. Consumers in OECD countries now expect to find a wide range of food available throughout the year, with only small seasonal variations, in contrast to the notable seasonal variation in the availability of fruit and vegetables that was once the norm (Huang and Huang, 2007).

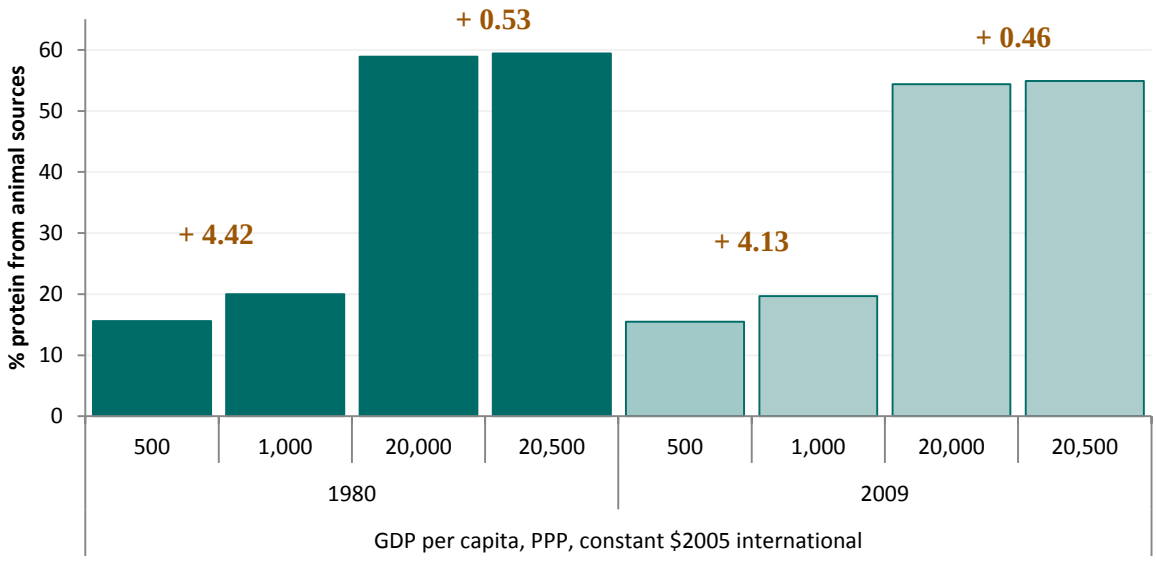
As ***incomes*** rise, the share spent on food tends to decline. At national level, for example, the average share of household income spent on food – not including alcohol or tobacco – is above 45% in Cameroon, just over 25% in India, and less than 15% in most OECD countries, with households in the

US spending on average little more than 7% of their incomes on food (USDA statistics, reported in *The Economist*, 15 March, 2013). Within countries, it is normal for those households with low incomes to spend a larger share on food than those with higher incomes. As incomes rise, the share of the overall household budget spent on food declines. At the same time, the elasticity of demand in relation to price tends to expand: households become increasingly indifferent to changes in price when considering what food to buy.

Higher incomes also change the composition of a household's diet. As people become wealthier, they switch from relatively low-cost starchy staples like rice, wheat, maize, potatoes and cassava, to meat, fish, dairy, fats and sugars that are usually more costly but seen as tastier. Higher incomes are expected to lead to higher consumption of complementary foods, particularly meat and other livestock foods.

National income can explain some 65% to 70% of variation in the average proportion of protein from animal sources by country[17] (Appendix 6 details a regression using data from 114 countries in 1980 and 2009). The relation between meat consumption and incomes is stronger at lower income levels, as shown in Figure 2.22. When average national incomes rise from $500 to $1,000, the proportion of protein from animal sources in the average diet rises by 4%; while the same increase in incomes when the average is $20,000 per capita is barely 0.5%. The increments are fractionally smaller for 2009 than for 1980, though this is of low significance (see Table A6.1 in Appendix 6).

Figure 2.22 Change in proportion of protein from animal sources from a $500 per capita average increase in income, 1980 and 2009



Source: Authors' calculations. Data can be seen in Table A6.1, Appendix 6.

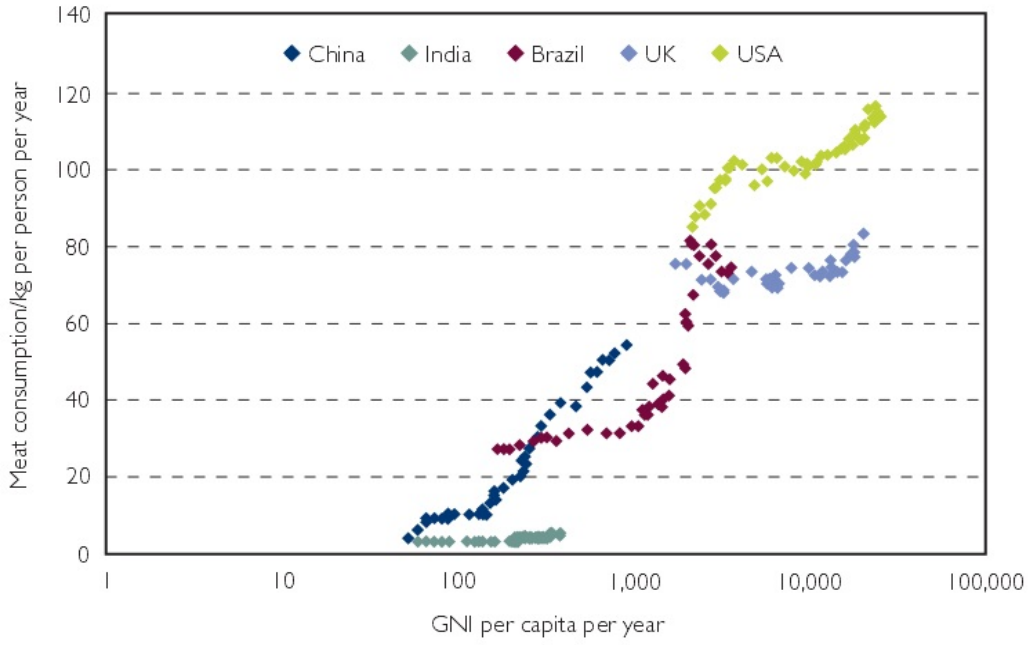
Figure 2.23 plots trajectories of meat consumption with increasing gross national income (GNI) from the early 1960s to 2007 for five countries: Brazil, China, India, the UK, and the US. In Brazil, China and the US, rising incomes are associated with more consumption of meat. The UK, however, already had high levels of meat consumption in 1961 and meat eating has increased only slightly with rising incomes. India is a clear exception in the case of meat, with very low consumption that has changed

[17] Log linear regressions with the proportion of protein from animal sources as the dependent variable and a measure of GDP per capita (a proxy for income) as the independent variable.

little as incomes have increased – a result of the vegetarianism that is part of the religious belief of so many Indians.

It is expected that increases in meat consumption will taper as incomes rise, a pattern that is already evident for China, as shown by the almost straight line of rising meat consumption against logarithmic increases in income. For Brazil, however, it seems that the tapering is less pronounced since the slope of meat consumption against log income steepened beyond an income threshold of US$1,000 a head.

Figure 2.23 Changing consumption of meat in relation to gross national income in Brazil, China, India, UK and US, 1961 to 2007



Source: Government Office for Science (2011b). Original sources: FAOSTAT; World Bank.

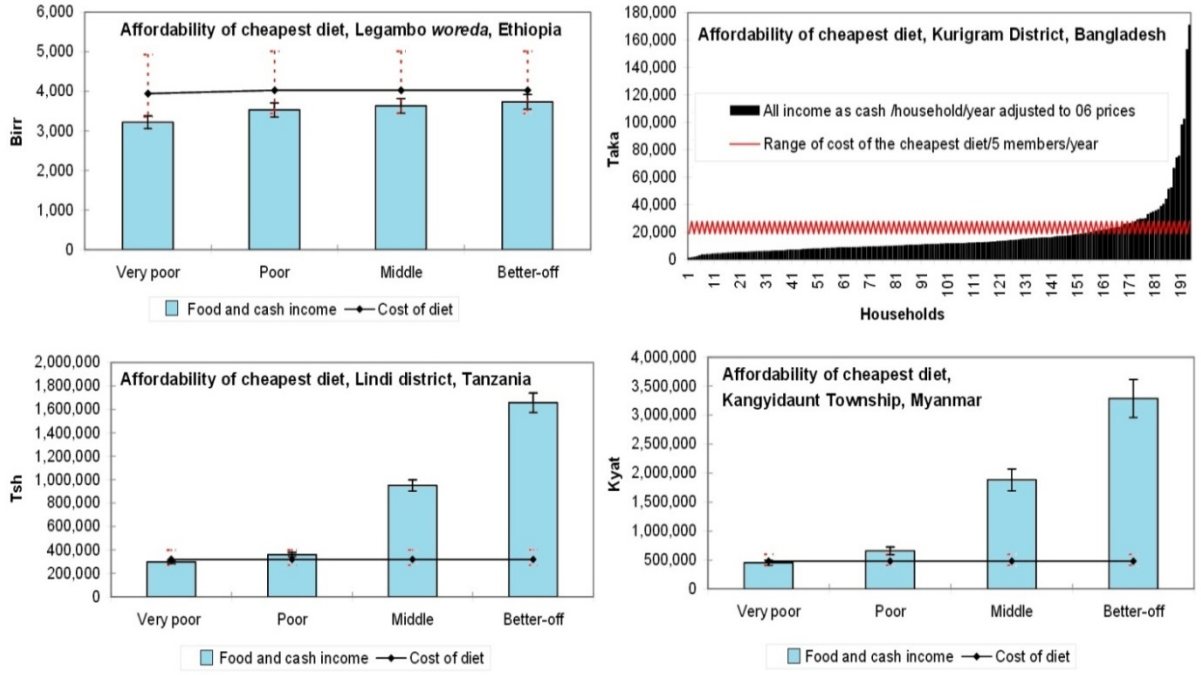
Note: Horizontal axis is logarithmic because marginal increases in meat consumption decline as income rises.

Affordability of diets

Even though the general tendency in both developing and industrialised countries for the past 50 years has been for the costs of many foods to fall and incomes to rise, this does not mean that an adequate diet is affordable for all. Some studies in developing countries suggest that even those people on low incomes should be able to afford an adequate diet. For example, Darko et al. (2010) used linear programming to identify a low-cost diet that would meet nutritional needs. However, a study by Save the Children in four towns in low-income countries – Bangladesh (Kurigam), Ethiopia (Legambo), Myanmar (Kangyidaunt) and Tanzania (Lindi) – found that poor people could not always afford an adequate diet (Chastre et al., 2007), as shown in Figure 2.24). The study reported:

> *'However, even with the conservative estimates presented, the diet remains unaffordable for large proportions of the population in all four study locations. While it is technically affordable in Myanmar and Tanzania, it remains unaffordable for a significant proportion of the population in Bangladesh and Ethiopia. Once estimates take into account basic non-food items needed for households to maintain a minimum standard of living, a healthy diet would become unaffordable for the majority of the population in all four locations.'*

Figure 2.24 Affordability of low cost healthy diets in Ethiopia, Bangladesh, Tanzania and Myanmar



Source: Figures 9 to 12 in Chastre et al. (2007).

In countries with higher average incomes, more attention is being paid to the quality of the diet, and in particular whether it contains enough micronutrients and whether there is a good balance between the major food groups. In South Africa, for example, a 'healthy diet' would cost 69% more than a typical South African diet (Temple and Steyn, 2011). For those households among the lowest third in terms of average incomes, the extra expense of a healthy diet would equate to fully 30% of their total income. Careful design of the diet, to take advantage of moderately priced sources of particular nutrients such as oats, beans, carrots and apples, might bring this down to 10%, but Temple and Steyn concluded that a healthy diet is unaffordable for most South Africans.

Even in high-income countries (HIC), people on low incomes may struggle to eat diets rich in fresh fruits and vegetables. Very often, the cheapest foods are processed and are high in fats and sugars, with a high energy content per dollar spent, but they are low in micronutrients. In Seattle, US, for instance, those who spent less on their food had diets that were nutritionally inferior, which may explain why those on lower incomes do not tend to follow dietary guidelines and have the highest rates of diet-related chronic disease (Aggarwal et al., 2012).

Similar results were seen in France, where data from the national food consumption survey were used to compare energy and nutrient intakes for different groups. People in the lowest quartile of spending on energy had the highest intakes of energy and the lowest intakes of key vitamins and micronutrients, while those in the highest spending quartile had lower energy intakes but had diets high in micronutrients. The difference in the costs of diets between the lowest and highest quartile was large: 165% (Andrieu et al., 2006).

In Australia, researchers found that the cost of having a healthy diet based on public health recommendations would take some 40% of the disposable income of families that were dependent on welfare, while families earning an average income would have to spend 20% of their disposable income to achieve the same healthy diets (Kettings et al., 2009).

Individual preferences and the factors behind them

Culture and religion have a strong influence on diets. Some religions prohibit consumption of specific meats, such as the Jewish and Muslim bans on pork. A combination of religion and culture explains the unusually high incidence of vegetarianism in India. A recent survey for 2006[18] (the Hindu-CNN-IBN State of the Nation Survey) found that 31% of Indians were lacto-vegetarians (consuming no animal products but milk), while another 9% were almost lacto-vegetarian (also consuming eggs). Even most non-vegetarians in India do not eat meat on a regular basis (Delgado et al., 2003; Goldammer, 2001).

In other cases, regional diets have emerged where the initial influences on diet may have been the availability of locally-produced foods, but became cemented by food processing and cooking that have become part of the local culture. In Europe, for example, we see strong contrasts between the diets of the North based first on grains and later on potatoes, with much dairy produce and animal fat; and the South where Mediterranean diets are rich in vegetables and olive oil. These differences persist, even though it has been possible to buy the main ingredients of either diet in either region for decades.

Much interest has been aroused by the way in which ***information*** now transmitted by mass media – and increasingly by social media – had led people to try and accept new foods. Cultural exchange in the past 50 years or so means certain foods that were once regionally specific, such as curry, pizza and sushi, are now common across the world.

Three streams of information can change diets. The first is **public education from governments** that aims to promote diets seen as healthy (this will be covered in more detail later in the section on policy).

The second stream is **curiosity**, as people learn about new foods, new ways to prepare food, and diets recommended for those trying to lose weight or to improve their athletic performance. If TV programming is any guide, many people in high-income countries enjoy learning about food and how it can be cooked. Television programmes and films may also influence diets less directly by showing aspirational characters consuming particular foods. The Teenage Mutant Ninja Turtles cartoon, for example, is credited with having created new demands for pizza across the world.

Commercial advertising is the third stream of information. Some food manufacturers invest heavily in advertising to influence food choices. Advertising varies considerably across foods, with little spent to advertise staples and unprocessed foods, and heavy advertising for some processed and branded foods. How influential this advertising is on the food choices people make is another matter: some heavily advertised products may also be quite cheap, easily available and feature in other information streams. If consumers buy them, it is not always clear that they do because of advertising.

Advertising aimed at children causes real concern. Examples include aggressive marketing of fast foods and sugary breakfast cereals[19] to children using bright colours, cartoons, free toys, and similar techniques. The promotion of potentially unhealthy food and drinks is now recognised in Europe as a significant risk for child obesity and for developing diet-related non-communicable diseases (NCDs) (Bollars et al., 2013). Some go further:

[18] FAO and USDA estimates vary from 20% to 42%.

[19] Sugar in some popular children's cereals is well above recommended levels. In the UK, the 'traffic light' label for 'high' sugar content is 12.5%. Kellogg's Frosties have 37% sugar; several own-brand chocolate rice cereals (including, for instance, Tesco Choco Snaps and Sainsbury's Choco Rice Pops) have 36% sugar. Kellogg's Crunchy Nut Cornflakes, Coco Pops, and Honey Monster Sugar Puffs all have 35% sugar content; while even cereals marketed as 'healthy' alternatives still exceed recommendations, including Kellogg's All-bran Flakes, which contains 22% sugar and Special K, which has 17% sugar (NHS Choices 2012).

'Nearly all food marketing to children worldwide promotes products that can adversely affect their health.' (Harris et al., 2009)

As well as direct marketing to consumers, parts of the food industry[20] lobby governments on regulations, labelling and public education about diet. The Guideline Daily Amount (GDA) for sugar that is in place in the UK is a case in point. At 90 grams a day, it seems too high when set against the NHS recommendations of no more than 70 grams of sugar per day for the average man and no more than 50 grams for the average woman (10% of calorie intake) (NHS Choices, 2013).

'One can of regular cola contains nine teaspoons of added sugar, which is triple the 2009 upper limit intake suggested by USDA for an 8 year old child. The UK GDA label describes these 9 sugar lumps as 39% guideline daily amounts. Based on this false reassurance, it would therefore be understandable for parents to be misled into believing that it would be safe for their child to drink two and a half cans a day. It's time for the UK's Scientific Advisory Committee on Nutrition and the Department of Health to act swiftly as the dietary advice on added sugar is in desperate need of emergency surgery.' Malhotra (2013)

Some draw parallels between 'big food' and 'big tobacco', particularly in the way that food processors deny that their products harm health (Brownell and Warner, 2009). The UK's Food and Drink Federation website denies a link between sugar and diabetes,[21] despite a firm conviction amongst the medical community that there is a link between excessive consumption of sugar and calorific sweeteners commonly used in soft drinks, and the risk of becoming overweight and developing type-2 diabetes, as well as other conditions including heart disease (see, for instance, Schulze et al., 2004; Apovian, 2004; Goran et al., 2012; Basu et al., 2013b; NHS Choices, 2013). In 2003, the US Sugar Association attacked the WHO's scientific credibility following the release of a draft report advocating that people eat more fruit and vegetables and limit their intake of foods with high fats and sugars, including limiting sugars added to foods that are not naturally sweet (Brownell and Nestle, 2004).

'It [the Sugar Association] also vowed to use "every avenue available to expose the dubious nature" of the report, including asking members of Congress to challenge the United States' $406 million in contributions to the W.H.O.' (Brownell and Nestle, 2004)

Not all advertising and industry lobbying supports foods that dieticians consider to be eaten to excess. Some commodity-specific advertising promotes the increased consumption of foods that are either beneficial or at least entail less risk. Examples include the '*Go to work on an egg'* campaign from the 1950s and 1960s in the UK, or the *'Got Milk?'* campaign that has been running since the early 1990s in the US.

Social changes in work and gender roles

Several social factors affect diet in addition to those already mentioned. Urbanisation can affect diet when people lose access to land on which to grow part of their own food. The wider availability of convenience foods in urban areas may encourage snacking outside the home, or buying-in pre-cooked

[20] In the US, groups including the *Grocery Manufacturers of America* represent the whole industry; while groups such as the *Snack Food Association* and the *American Beverage Association* represent general types of food; groups like the *National Restaurant Association* represent segments of the food industry; and groups including the *Sugar Association* and the *Corn Refiners Association* represent specific foods (Brownell and Warner, 2009).

[21] 'While neither starch nor sugars have been found to have any special role in the development of serious diseases such as diabetes it is still important to keep an eye on their intake if you are already suffering from some diet-related medical condition, if you are watching your waistline, and to limit the risk of tooth decay.' (FDF, accessed 2013)

food. Longer journeys to work mean that meals are eaten at the work place or in canteens, where once people in villages would have gone home to eat.

As the proportion of women in the workplace grows, women may be left with less time to prepare meals – a role that they still carry out in many countries, if not most. They may, therefore, favour foods that can be cooked rapidly, such as pasta, and shy away from those that take time, such as boiling pulses. Processed foods, often high in salt or sugar, may be preferred for their ease of preparation. Alternatively, food may be bought in from fast-food outlets, many of which sell foods that are high in fat, salt and sugar.

Globalisation in the form of liberalised trade, investment and information flows

The liberalisation of trade in goods, services and capital, coupled with increased flows of information, has led to greater connections across countries and regions in processes summarised as 'globalisation'. Four aspects of globalisation, in particular, affect diet (Hawkes, 2006).

First, ***trade***, as this changes the domestic availability and price of foods: either allowing countries to import cheaper foods that already form part of the diet, or else to import a novel food. From the early 1970s to the early 2000s, the prices of most foods on world markets fell in real terms, leading to falling real prices on domestic markets. Prices have risen since the cereals price spike of 2007-2008 on world markets, but they are still well below their 1990 levels. More specifically and recently, trade has allowed the growing Asian economies to import cheaper vegetable oils and soybeans for oil and animal feed, thereby encouraging increased consumption of fats and animal produce.

Second, the ***foreign direct investment*** that has seen multinational companies investing in food processing and retailing, especially in emerging middle-income economies. This can lead to more choice of food and lower costs for consumers (Mazzocchi et al., 2012) but there is some concern that it may also influence the composition of the food that is being bought, steering it towards less healthy diets.

A much-cited example is Mexico, where the North American Free Trade Agreement (NAFTA) that came into force in the early 1990s has seen much US investment in Mexican processing and retailing, with increasing domination by US chains not only of supermarkets but also of urban convenience stores. Since that time there have been alarming increases in the consumption of fats and refined carbohydrates – with sugary soft drinks to the fore. The share of Mexicans considered overweight or obese had reached 59% by 1998, with an upsurge of type-2 diabetes, affecting 8% of the population (Hawkes, 2006).

The third example of globalisation's impact has been in ***marketing expertise***, with multinationals and their local subsidiaries spreading successful tactics in the distribution and advertising of processed foods from one territory to another. A concern here is that advertising may target children in countries where there are as yet few controls on influencing the young: Thailand being a case where snack-food commercials are directed towards minors (Hawkes, 2006).

Fourth is the effect of ***films and television programmes*** in forming preferences, as set out in the previous section.

How important is globalisation in influencing diets? It is difficult to untangle the influence of these forces from all the other changes, such as urbanisation and higher incomes that influence diet. Some see a strong link:

> *'While it is difficult to show causation between globalization trends and changes in diet, there is convincing circumstantial evidence that companies create these changes rather than simply responding to latent demand. The impact on nutrient intakes is not well-established, even in developed countries, though processed foods, fast foods and soft drinks have been linked to the nutrition transition and the obesity epidemic, and they are also likely to influence nutrition outcomes in poorer countries.*

'Evidence points at globalization as the dominant force for dietary change, prompted by international investment liberalization and trade reform. Beyond its major influence on prices and incomes, globalization has a critical impact on preferences and lifestyles, with a growing range of available food to meet new demands. These changes have been complemented and facilitated by growing urbanization and demographic change (most notably increased workforce participation of women).

'While the effects of multilateral trade agreements have favored globalization trends in food systems, and may have induced changes in diets by altering relative prices, the most relevant impacts are likely to be the indirect ones driven by the expansion of non-agricultural trade and global economic growth. Traditional trade liberalization models indicate relatively minor price changes for agricultural commodities, while generating more substantial effects on diets through income growth, changes in food systems and increased availability of processed foods.' (Mazzocchi et al., 2012)

As will be seen in the final part of this chapter, this may be overstating the case.

Government policy

Governments can affect diet directly through policies and programmes that range from the influence of public education to more direct controls on the production and marketing of particular foods. By and large, government policy to date has not played a strong role in diets in most countries, either because policy initiatives have been limited in both aims and scope or because they have had little effect. States have not, as yet, seen diet policy as a priority that requires strong public action.

Indirectly, however, public policies and investments have had a strong impact on diets through, for example, the promotion of agricultural technology and investments in physical infrastructure that have helped to lower the costs of food production.

Policies directed specifically at diet and their effectiveness will be reviewed in Chapter 3.

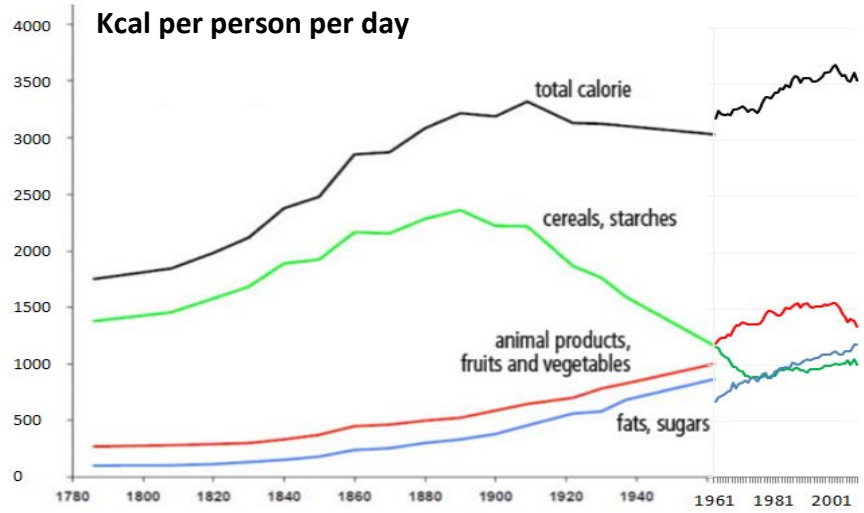
Combining ideas: diet transitions and the food environment

Some of the factors discussed so far – biology, economic access, individual preferences, work patterns and gender roles, globalisation, the food environment – show clear trends through time, and some of them also interact with each other. So are there overarching theories of change in diet? Two strands of thought can be picked out.

One concerns ***dietary transitions***, an idea developed by Barry Popkin and his collaborators (Popkin et al., 2001; Popkin, 2003; Popkin and Ng, 2006). Here, the main drivers of changing diets are economic growth and rising incomes, accompanied by urbanisation and more sedentary lives. Modern history shows that as incomes rise, diets tend to move from those based on grains, roots and tubers with only modest livestock consumption, to ones with higher consumption of oils, fats, sugar and livestock products – and with a corresponding reduction in the consumption of cereals and other starchy staples.

Consider, for example, changes in the share of different foods in France from 1780, just before the French revolution, to 2009, as shown in Figure 2.25. In the eighteenth century, French diets were dominated by cereals, roots and tubers. In addition, total calorie intake was not, on average, sufficient to guarantee that everyone would have enough energy. During the nineteenth century, economic growth saw increases in the provision of staple cereals and starches, as well as increases in complementary foods from animal products, fruits and vegetables, fats and sugars. Initially, therefore, the main change in the diet was the increasing availability of dietary energy, with only a small decline in the dominance of staples in the diet. After about 1890, however, staples began to decline in relative importance, while the consumption of complementary foods rose both relatively and absolutely. By the end of the twentieth century, the availability of total energy was high, with animal produce, fruit, vegetables, fats and sugar contributing more to energy than cereals and starches.

Figure 2.25 Long-term evolution of food-group availability in France: 1780 to 2009



Source: Figure to 1960 from Figure 1 in INRA, 2010 (Original source: P. Combris, based on J.C. Toutain). Data from 1961 to 2009 from FAOSTAT, hence the small disjuncture between the two datasets at 1960/61.

So diets in France have made a considerable transition over the past 200 years, from diets heavy in staples to those rich in animal products and other complementary foods. Similar trends have been seen in most industrialised countries as they made the transition from being largely rural and agrarian, to becoming urban and industrialised.

The transition is not just a matter of changes in food consumption. It is usually accompanied by a shift towards more sedentary lives. The combination of these changes can also contribute to an epidemiological transition:

> *'… from endemic deficiency and infectious diseases (for which poor nutrition is a risk factor), toward diet-related chronic diseases, including ischemic heart disease (IHD), diabetes, obesity, hypertension, stroke, and certain cancers' (Popkin et al., 2001).*

This dietary transition has seen a pronounced shift in focus, from concerns with undernutrition and infectious disease to a focus on increasing rates of overweight and obesity and on the rise of non-communicable diseases to which unbalanced diets – too rich in fat, salt and sugar – probably contribute.

The second strand of thought also concerns affluent societies in industrialised countries, where food environments have been called ***'obesogenic'*** (Lang and Rayner, 2007; Lang, 2009). Higher incomes and more sedentary lifestyles, coupled with changes to the ways in which food is produced, advertised and retailed, have created an environment that more or less ensures that many people will become overweight and obese.

On the supply side, favoured foods from traditional diets that are often rich in fat and sugar and that may well have been appropriate for adults engaged in active, manual labouring are now too high in energy for current demands. Yet they remain popular. Food processers have become highly effective in producing foods, including snacks, that cater for popular taste and are able to market them at low cost. As food processors struggle to get and keep their market share and recoup investments in product development, they advertise these foods heavily. Food retailers contribute to the availability and low cost of these foods, as there are profits to be made in selling them in high volume, given that processer

advertising should ensure demand. Fast-food outlets have also developed tasty foods at low cost, but, as mentioned, these are often foods that are dense in energy and high in fat, salt and sugar.

On the demand side, consumers now have more income to buy food. As we have seen, many feel less inclined to spend time preparing food at home, preferring instead to buy in food or to eat processed food that requires little or no cooking. Investments in transport, and above all the rise of the personal car and increasingly sedentary leisure time as people watch television or computer screens, leave many consumers in high-income countries expending so few calories that it is difficult to eat without accumulating weight. Today's diets in high-income countries are not only excessive in energy, but overly rich in fat, salt and sugar, while being undersupplied with fibre, minerals and vitamins.

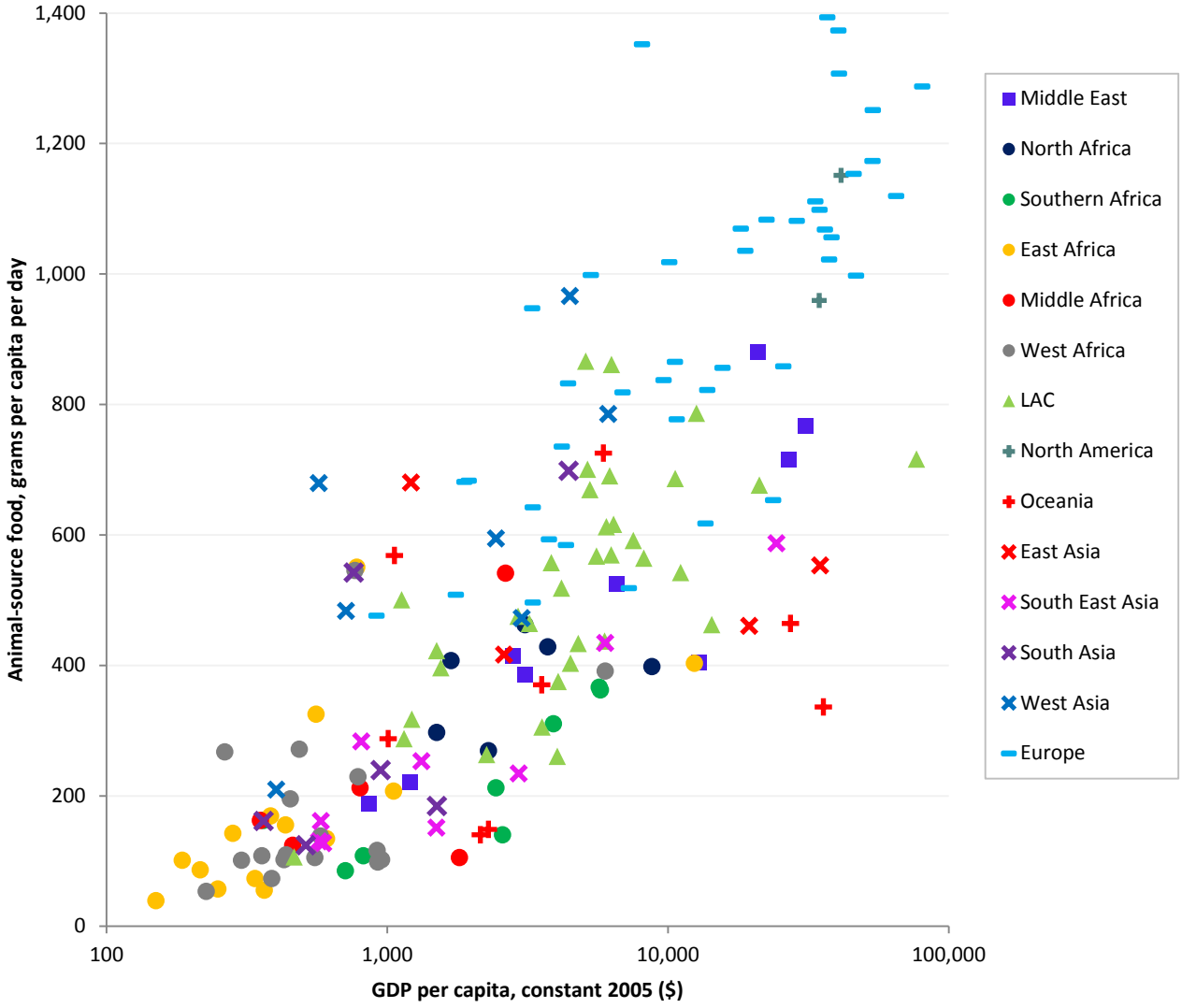
Diets: choice or determinism?

Ideas about dietary transitions, the effects of globalisation and the creation of obesogenic environments can give the impression that diets across the world will lead inevitably, given expected economic growth and urbanisation, not only to dietary convergence but also to diets that are unhealthy. So is it the case that diets are becoming more uniform across the world? And if so, can we assume that the diets that are evolving today in middle-income countries and that will surely evolve tomorrow in low-income countries, will resemble the diets that have been adopted already in many industrialised countries?

The differences we have noted in diets of our five selected middle-income countries suggest that it is far from obvious that diets are converging on some global norm. To review this more closely, we first consider the effect of average incomes on the consumption of animal produce looking across countries with different levels of income, before running a simple test for convergence through time.

As we have seen, the average consumption of animal produce rises as incomes rise (Figure 2.26). It is also clear, however, that countries do not lie on or close to any single line or trajectory: many countries have more or less animal-source food than might be predicted from income alone. Regression analysis that looks at the influence of income per person, with controls for regions, explains almost 80% of the variation in consumption of animal products seen across regions (Table 2.1).

Figure 2.26 Average per-capita consumption of animal-source food compared to GDP per capita, 171 countries, 2009



Source: Authors' construction, data from FAOSTAT and World Bank WDI.

Note: Horizontal axis is a log scale.

Table 2.1 Regression of average incomes on animal-produce consumption by weight, 2009

Adjusted R Square	**0.79**		
Observations	171		
	Coefficient	*P-value*	*Significance*
Intercept	3.54	0.000	***
ln GDP	0.31	0.000	***
Regional dummies: (East Asia as control)			
South East Asia	-0.40	0.085	*
South Asia	-0.08	0.739	
West Asia	0.49	0.041	**
East, West, Middle Africa	-0.51	0.016	**
Southern Africa	-0.60	0.010	**
North Africa	-0.07	0.761	
Middle East	-0.12	0.581	
Europe	0.34	0.088	*
North America	0.18	0.581	
LAC	0.05	0.814	
Oceania	-0.06	0.793	

Source: Data from FAOSTAT.

*Note on significance *** = 99%, ** = 95%, and * = 90%.*

East Asia is chosen as the 'baseline' to which other regions are compared as it is a region with relatively medium incomes and animal consumption compared to other regions that can be singled out for being especially low or especially high.

Incomes have a strong and significant influence on the consumption of animal products. In some regions, the amounts consumed differ significantly as a result of the effect of income alone. More animal produce is consumed in Europe and West Asia, and significantly less in Southeast Asia and most of Africa, compared to East Asia.

However, equivalent regressions for animal produce broken down into its components of meat, milk and dairy (see Appendix 6), and fish and seafood show less explanation by income and regional dummies, even if the coefficient for income is always highly significant. This suggests that different types of animal produce tend to substitute for one another. The relation for fish is the weakest of all: if this model can explain 79% of the variance for all animal produce, this falls to just 46% for fish and seafood.

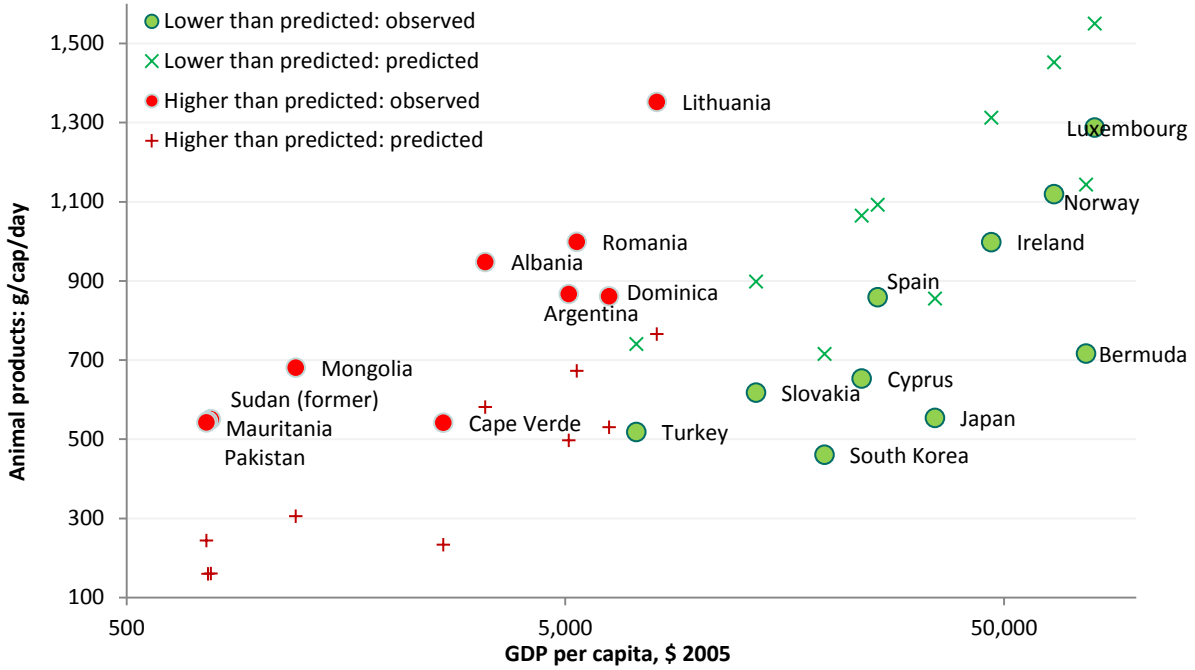
Some countries have average consumption of animal produce that varies considerably from what can be predicted from their incomes and regions. Table 2.2 shows the top 10 outliers at each end of the distribution scale from the regression depicted in Table 2.1 and in Figure 2.27.

Table 2.2 Outliers: countries with animal-source food consumption that is not well predicted by income and region, 2009

	GDP, 2009 ($2005/cap/ year)	Observed animal product (g/cap/day)	Predicted animal product (g/cap/day)	Difference between observed & predicted (g/cap/day)
Top 10 countries with lower than predicted consumption of animal products				
Bermuda	76,955	716	1,143	427
Cyprus	23,700	653	1,064	411
Norway	65,088	1,119	1,452	333
Ireland	46,773	997	1,312	315
Japan	34,822	553	855	302
Slovakia	13,622	617	898	281
Luxembourg	80,537	1,287	1,550	263
Republic of Korea	19,489	460	715	255
Spain	25,762	858	1,092	234
Turkey	7,267	518	740	222
Top 10 countries with higher than predicted consumption of animal products				
Lithuania	8,082	1,352	765	-587
Sudan (former)	779	550	160	-390
Mauritania	767	545	159	-386
Mongolia	1,215	680	305	-375
Argentina	5,096	866	496	-370
Albania	3,288	947	580	-367
Dominica	6,300	861	530	-331
Romania	5,310	998	672	-326
Cape Verde	2,638	541	233	-308
Pakistan	761	542	243	-299

Source: Authors' calculations with Data from FAOSTAT.

Figure 2.27 Outliers: countries with animal-source food consumption that is not well predicted by income and region, 2009



Source: Authors' construction with Data from FAOSTAT.

Some outliers are the result of national characteristics that are not captured by the model shown in Table 2.1. For example, Mauritania, Mongolia and Sudan are amongst the outliers where animal consumption exceeds expectations, but all three are countries with high incidence of pastoralism where diets have always relied heavily on dairy and meat. In some cases, the outlier exists because the model does not capture the full curvature of the relation between income and animal-product consumption. Norway, for example, has high animal intake but the model predicts that it should be much greater, given the country's very high income. But at this end of the distribution, the curvi-linear relation of income to animal-product consumption may well be close to completely inelastic.

Yet the main observation from these outliers is heterogeneity: there is no single missing variable, or group of variables that would explain these deviations. What we have is a mixed bunch of countries that defy ready classification. And what they tell us is that, independently of income and regional location, the extent to which diets contain animal produce can vary considerably. Diets are determined partly by income and location, but they are also influenced by many other factors.

Diets may differ, but are they converging through time towards a worldwide norm, as those who see globalisation as so important might argue? This can be tested by looking at the determinants of animal-produce consumption in 2009 and almost 30 years earlier in 1980, for 121 territories for which data is available in both years. Comparing the models estimated for the two periods, that for 2009 is a slightly poorer fit to the data; while the parameter for income has weakened. There is, therefore, no sign diets are converging on some global norm If anything, diets may be less 'explainable' by an overarching factor such as income, which may be a proxy for the influence of globalisation, given that one might expect more food trade, FDI and information to flow in richer countries.

On the other hand, fewer regional dummies are as significant or as strong in 2009 than they were in 1980. This might indicate that regional norms are less influential and that global norms are more powerful; or it could indicate that there is greater country heterogeneity within each region. This result is ambiguous.

Table 2.3 Testing for convergence in diets: determinants of animal-produce consumption, 1980 and 2009

Dependent variable: animal produce consumption by weight	**1980**			**2009**		
Adjusted R Square	0.81			0.78		
	Coefficient	P-value	Significance	Coefficient	P-value	Significance
Intercept	2.49	0.000	***	3.16	0.000	***
Income (GDPPC)	0.36	0.000	***	0.32	0.000	***
Regional dummies (East Asia as control)						
East, West, Middle Africa	0.19	0.407		-0.22	0.411	
Europe	0.87	0.000	***	0.54	0.028	**
LAC	0.65	0.003	***	0.35	0.152	
Middle East	0.38	0.157		0.20	0.494	
North Africa	0.36	0.171		0.27	0.368	
North America	0.79	0.021	**	0.43	0.233	
Oceania	0.70	0.007	***	0.27	0.338	
Southern Africa	0.40	0.116		-0.25	0.368	
South Asia	0.38	0.165		0.12	0.707	
South East Asia	0.04	0.884		-0.10	0.724	

In sum, while income is clearly a strong driver of the amount of animal produce consumed, and while regional characteristics do matter, national diets can diverge considerably from the norms implied by this model – and from the dietary transition sketched by Popkin, where income plays a strong role. The implication is that globalisation certainly has an influence, but that wide regional and inter-country variations leave more scope than might be imagined for national policy to influence the evolution of diets. The next chapter will examine the scope for public policy.

Conclusions on diets and their determinants

In conclusion, how close are the diets we see today to the diets that are recommended? The past 50 years have seen considerable increases in the amount of food available per person, across all food groups, and for the world as a whole. For people on high incomes, food has become abundant and they can choose their diet with few concerns about its cost. With economic growth, rising incomes and urbanisation, diets have tended to follow a transition from those based on meeting energy needs through heavy consumption of grains and starchy staples, to those where the average consumption of these has fallen to be replaced by more fruit and vegetables, but above all, by more animal produce, and more oils, fat and sugar.

Yet although such general patterns are evident, the continued dietary variation across countries reflects national food cultures and preferences, and there is further variation within countries by economic and social group and by district.

The typical diets across the world, when compared with the diets recommended for healthy and active living, have more than enough grains but are usually low in dairy and fruit. In high-income countries, such as the US, the consumption of oil, fat and sugar is well above recommended levels. At the other end of the scale, LDCs have average diets that are short of fruit, vegetables, dairy and other protein-rich foods, such as fish and meat.

Diets are influenced by a plethora of factors that can be grouped in half a dozen categories: human biology and physiological needs; costs of food and incomes; preferences formed by culture, religion, information and advertising; social changes in work patterns and gender roles; globalisation and its influences through trade, investment and information; and public policy.

Perhaps the most interesting question here has been the extent to which growing incomes and expanding globalisation are leading to the convergence of diets on some international norm or, conversely, the extent to which diets remain heterogeneous by country, social groups and individual. It would be perverse to deny that rising incomes and urbanisation tend to lead to diets rich in animal produce, fat, salt and sugar, or that the various influences of globalisation including advertising and media can have a significant impact on diets. Yet national diets are not necessarily converging on a single international norm – indeed, it may be that income is becoming a weaker determinant of diet over time. The welcome implication is that there may be considerable scope for public policy to have a real influence on diets.

3 Public policy and diet

Many policies influence diets indirectly, above all by affecting the price of food. These include the many policies that promote agricultural development and the public investments in roads and ports that support improved logistics and lower unit costs for food distribution. The focus in this chapter, however, is on specific measures that have specific dietary objectives.

Policies for diets can be categorised by the means used, dividing them into: information designed to affect individual choice of foods; price incentives to change the cost of all or specific foods, together with income measures to make foods more affordable; and restrictions and rules on food processing, advertising and retailing. A second division can be made between those measures that seek to remedy undernutrition, seen primarily in the developing world, and those that try to reduce the consumption of foods that can lead to obesity and illness when consumed to excess and, correspondingly, encourage consumption of healthier alternatives. Taking these two criteria together we arrive at the typology set out in Table 3.1.

Table 3.1 Typology of policies to influence diets

	To reduce undernutrition	To reduce excess consumption and/or encourage healthy diets
Public information and education Labelling Food guides	Public information through health clinics, posters, radio, and television – often with a focus on young mothers, weaning foods and care.	Public information through posters, radio, and television – may include messages such as 'five a day' for fruit and vegetables, recommended diet composition, recommended diet balances in food plates, rainbows and pyramids. Labelling of foods: their ingredients, nutritional contents, traffic-light warnings. School and hospital meals: ensuring that school children and patients get healthy meals.
Price and income incentives Alter choices by changing the absolute and relative prices of foods	*Cost of food:* Subsidies – usually on staple foods – to ensure that the poor have access to an adequate diet, through public distribution systems. Public storage of staples to reduce price variations. Trade measures: tariffs and quotas to keep domestic food prices low. *Incomes and direct entitlement* Social protection: cash transfers, food vouchers, or food for those in danger of losing access to food – sometimes linked to public employment. School meals to ensure that pupils get at least one sufficient meal a day.	*Cost of food:* Minimum price regulations for foods that have a high risk of over-consumption. Particularly fats and sugars, as well as taxes on such foods. Subsidies to encourage the consumption of foods seen as healthy. *Incomes and direct entitlement* Food stamps for those on low incomes who are in danger of losing access to food, or to a sufficiently wide variety of foods.
Rules and regulations Rationing Food processing rules Advertising controls	Rationing in centrally-planned economies. Mandatory micronutrient fortification, e.g. iodisation of salt, iron in bread.	Rationing to restrict the levels of food consumed (e.g. UK in WWII). Mandatory micronutrient fortification, e.g. iodisation of salt, iron in bread. Limits on industrially-produced trans-fats. Control on the advertising of foods with a high risk of over-consumption to children – particularly fats and sugars. Prevent the location of fast-food shops close to school gates. School and hospital meals: regulating their content, limiting access to higher risk foods.

Source: own elaboration, drawing partly on classifications seen in Capacci et al. (2012), and Haddad (2003) reporting Sims (1998).

Policies and their effectiveness

What is known about the incidence of policies used, and their effectiveness? In short, not enough. The evidence is imperfect: we did not find any ready source that documents the policies adopted by different countries; while evaluations of the effectiveness of measures are often lacking and of low quality – with perhaps the worst failings being the absence of counter-factuals coupled with pervasive selection bias[22] (Capacci et al., 2012). These gaps and deficiencies may reflect the generally low priority that diet policies receive in most countries.

Information and education

The most common measures relate to the domain of information and education, where messages are disseminated through general media, schools or health points when, for example, young mothers bring their infants to health centres for checks. The messages in developing countries often focus on the care and nutrition of infants, and above all on breastfeeding and weaning practices. In industrialised countries, however, the focus tends to be on healthy diets. Messages include the need to: consume balanced diets with adequate but not excessive quantities from the main food groups, often illustrated with visual reminders in the form of food pyramids, plates and rainbows; avoid excess consumption of foods that have high risks for some cancers, cardio-vascular disease, diabetes and strokes – above all fat, salt and sugar; and ensure the sufficient consumption of foods rich in fibre, and fruit and vegetables, as seen in the 'five [portions] -a-day' campaigns.

Education is often reinforced by mandatory food labelling that includes lists of ingredients, a comparison of nutritional content with recommended daily intakes, and the use of traffic-light codes to indicate the risks of over-consumption of fat, salt and sugar. Education about diet may also be linked to messages about the benefits of physical exercise.

Although some reports and studies find that people eat more fruits and vegetables if they have information about nutrition (Howard, 2011), a review of the effectiveness of these measures in OECD countries reports only limited impact (Capacci et al., 2012). The promotion of fruit and vegetables, for example, has rarely generated any greater response than a single additional portion eaten daily. While campaigns directed at schoolchildren may have greater effect than more general education, there is little to show their overall effectiveness in food consumption beyond the school gates. Labelling may or may not work, but studies are bedevilled by self-selection: those reporting that they pay attention to labels may well be those who already buy food with their health in mind.

Some studies report the strong influence of parental example, with parental education seen as a significant modifying factor for the impact of public communications. Educational attainment among American and French adults has been seen as a strong determinant of fruit and vegetable consumption (Tamers et al., 2009); as it was for Australian women (Ball et al., 2005). The education of mothers or parents has also been linked to their children eating more nutritious and diverse diets: see, for example, Khanal et al. (2013) on Nepalese infants or Vereecken et al. (2004) on Flemish pre-schoolers. In addition, parental education that improves infant complementary feeding practices has been shown to lead to positive outcomes on child growth – if households can access sufficient food. In a poor peri-urban area of Peru where sufficient calories were available, nutrition education led to lower stunting among the children of the families that received nutrition education compared with control groups (Penny et al., 2005). In rural Sichuan, China, where household food resources were not limiting, nutrition education led to better weight for age, height for age and anaemia scores in children at 12 months (Guldan et al., 2000). Lack of knowledge about correct feeding practices may not be the

[22] Selection bias arises when those evaluated as subjects of a programme have not been randomly assigned, but instead have been selected to participate either by those running the programme or by their own voluntary application to join. The treatment group may not then be representative of the general population. For example, if a programme to encourage people to take more exercise were evaluated by looking at the impacts on the fitness of people who had been offered free access to a gym, those taking advantage of the free gym might well be those who normally exercise and already have above average fitness, rather than some random selection of the population.

most important limiting factor for child growth in other cases: see for instance Bhandari et al. (2004), who found that while it was possible to improve complementary feeding practices though educational interventions in Rural Haryana, India, the effects on child growth were limited.

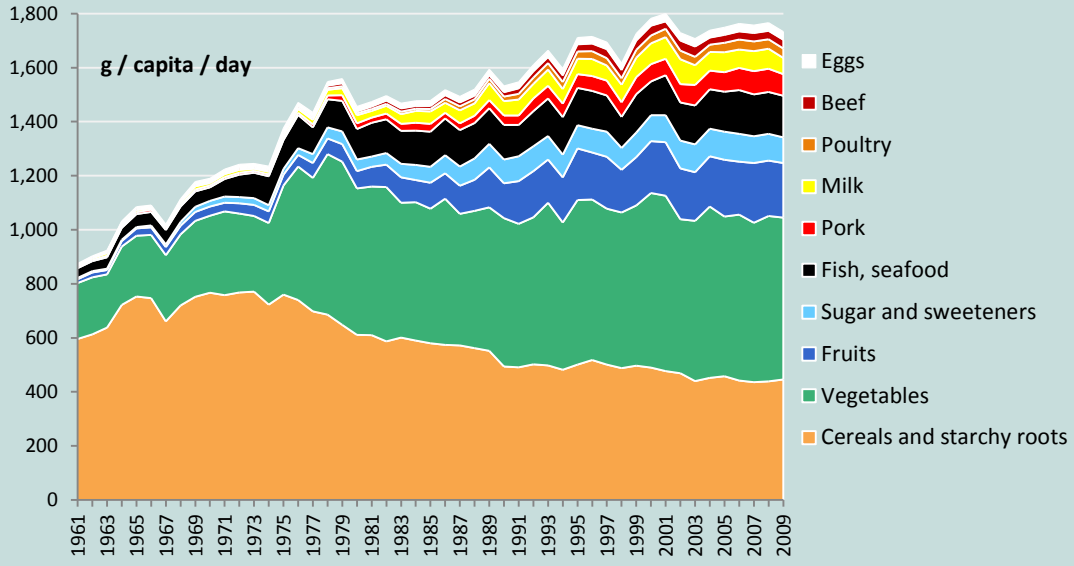
It is difficult, however, to judge the effect of public education without some measure of the intensity of the effort and of the influence of other measures to reinforce the messages. However, South Korea's unusual nutrition transition, shown in Box 3, demonstrates that a determined effort to conserve the nutritional advantages of the traditional diet, with its abundant vegetables and low use of fat, can pay off.

Box 3: Preserving traditional and healthy diets in the Republic of Korea

South Korea has tried to preserve healthy elements of its traditional diet. Publicity, education and social marketing have been used, including the large-scale training of women in the preparation of traditional low-fat, high-vegetable meals. As a result, South Korea has taken an unusual path through the nutrition transition (3.1).

Vegetable consumption is high and increasing, as is that of fruit; while fat consumption is relatively low – thanks, in part, to the modest consumption of animal products. Koreans also get a lower than expected average fraction of their energy from fat. At 19% this was almost 17 percentage points lower than the level expected when examining the relationship between GNP per capita and dietary fat intake for 121 countries in 1996 (Popkin and Ng, 2006). South Korea also has a lower incidence of obesity than expected, given its income level. In addition, the dietary diversity among Korean schoolchildren has responded positively to nutrition education (Yoon et al., 2000).

Figure 3.1 Average food intake, Republic of Korea, 1961 to 2009



Source: FAOSTAT data.

Overall sources: Kim et al. (2000), Lee et al. (2002).

Price and income incentives

In the ***developing world***, the aim has been to ensure access to food for people on low incomes, whose diet is vulnerable to price rises, other demands on the family budget and loss of income. Some countries have taken determined measures to ensure that the price of a basic diet is affordable. Typically, they have combined public stores of staples, partly to stabilise prices across seasons, but more importantly to hedge against domestic harvest failures. They have also introduced schemes to allow those on low incomes a rationed weekly or monthly allowance of cereals, oil, sugar, pulses and sometime kerosene for cooking, at controlled prices below the market level. Such initiatives are often backed by a willingness to ban exports if there are fears that these might allow international price rises to transmit to domestic prices. These measures can be costly, depending on how many people are entitled to public rations and how deep the subsidy is: there are clear political temptations to widen the net and to control prices in current terms as inflation proceeds so that the subsidy becomes ever more generous. Countries that have used one or more of these measures include China, Egypt, India, Indonesia and Mexico. Given the costs, and the demands for administrative capacity, they are more common in lower middle-income countries than in low-income countries: few countries in sub-Saharan Africa, for example, have such policies.

These measures can increase the access of the poor to food (see, for example, Kattumuri, 2011, on India's experience). That said, studies that look at the benefit-cost of subsidised food have concluded that their benefits are delivered at a high cost. If the aim is to reduce poverty, cash transfers might be preferable. For India, it is claimed that the Food Corporation of India delivers just one rupee of benefit for every five rupees of its budget (Farrington et al., 2003).

Just a few studies assess such schemes in terms of the quality of the resulting diet. For Egypt, Asfaw (2007), cited in Dangour et al. (2013), calculates a significant 10% elasticity of mothers' body mass index (BMI) to the price of subsidised bread[23] and sugar in the public distribution system. So if the price of these foods were to double, the BMI would fall by 10%. It seems that subsidies encouraged those on low incomes to consume energy-dense foods, rather than healthier options.

Developing countries have also used cash transfers, food vouchers and food aid as ways to ensure that the very poor have access to sufficient dietary energy, especially during lean seasons or when shocks (economic or natural) have resulted in the temporary impoverishment of those already on low incomes. The transfers often require beneficiaries to work on public schemes, although in middle-income countries they may require beneficiaries to comply with other conditions, such as sending school-age children to school and bringing infants to health clinics for regular checks.

Such transfers, when sufficiently large, can make considerable differences to the welfare, as well as the nutrition, of those on low incomes. Mexico has had perhaps the best-known example of a conditional transfer scheme, *Oportunidades*, since the 1990s (Box 4), with significant nutrition gains. Brazil set up a similar scheme, *Bolsa Familía*, in 2003 that has also received wide admiration for improving the welfare of those on low incomes – reaching no less than 12 million households.

[23] The price of subsidised *baladi* bread is exceptionally low: reported as one US cent for a loaf in 2013. It has long been reported that the price is so low that people in Cairo have used loaves to fatten poultry in their backyards.

Box 4: Mexico's *Oportunidades* conditional cash transfers

Beginning in 1997 under the name 'Progresa', Mexico's *Oportunidades* programme aims to assist households on low incomes, which are identified as eligible through strict targeting. Around 6.5 million households are enrolled in the programme, most of them in rural and semi-urban areas.

Cash transfers are the heart of the programme. Paid monthly, and usually to mothers, the transfers are conditional on children under 18 being enrolled in school with regular attendance, while infants and their mothers must participate in health education and checks. Pensions for those over the age of 70 and savings accounts for youth have been added in recent years.

External evaluations of *Oportunidades* have revealed positive results, including: reduced poverty rates among the participating households; more children in secondary education; fewer drop-outs and more use of health facilities. Girls, who get higher rates of subsidy, seem to have benefited in particular from the programme: their educational indices have increased more than the boys.

Disease has been reduced and nutrition has improved. Barquera et al. (2006) reported less disease amongst preschoolers, increases in the proportion of pregnant women attending health centres, reduction in morbidity among adults, and reduction in anaemia in under-twos. Cash transfers to women in poor urban areas led to higher consumption of foods rich in protein, with a larger effect than predicted (Angelucci et al., 2012). In poor rural communities, cash or equivalent transfers in-kind over 14 months led households to increase their energy consumption by 5-9%, while the energy gained from fruits and vegetables rose by 24-28%, and from animal source foods by 24-39% (Leroy et al., 2010). In addition there was significant improvement in the consumption of iron, zinc, vitamin A, and vitamin C.

Might the programme encourage adults, with their cash transfers, to work less? Apparently not, as reported Skoufias and di Maro (2006) on the basis of surveys of 320 localities where *Oportunidades* was implemented, compared with 186 control localities.

What about the impact on child labour? Bando et al. (2005) looked at the most serious dimension: child labour amongst indigenous groups, who are both poorer than most Mexicans and more likely to have their children out of school and in work. They found the programme to be effective in reducing child labour rates, and especially so among indigenous communities. As more indigenous children went to school, so the gap narrowed between them and other Mexican children.

In addition, many developing countries offer meals at schools for pupils, partly to ensure that they get at least one decent meal a day, partly to encourage attendance, and partly to improve their attention in the classroom. Although school feeding can be ineffective when implemented without enough regard for the circumstances of pupils, well-designed programmes can prove very effective, especially when accompanied by additional measures to improve the nutrition and health of school children, such as deworming (Bennett, 2003).

There are comparable programmes in ***OECD countries***, to protect the access to an adequate diet for those on low incomes, with the US food stamp programme the largest and best known. There have been proposals in recent years to direct the stamps towards healthier diets (Box 5), with more success in positive incentives to eat more fruit and vegetables than in restricting the purchase of sugary drinks.

Box 5: Using Supplemental Nutrition Assistance Programme (SNAP) to encourage healthy diets in the US

The largest programme in the US national nutrition safety net, the ***Supplemental Nutrition Assistance Programme*** (SNAP), began more than 50 years ago with the 1964 Food Stamp Act. In an average month in 2012 SNAP served over 46 million low-income people (USDA, 2013a). Eligible households on low incomes receive credit via Electronic Benefit Transfer (EBT) cards that can be used in around 250,000 retailers. The budget for SNAP in FY 2012 was $86.5 billion (for benefits, administration, with a $3 billion contingency).

In recent years the United States Department of Agriculture (USDA) has been urged to allow pilot programmes that restrict the purchase of fizzy, sugary drinks by SNAP recipients (see, for example, CSPI, 2013). USDA denied a previous request from the State of New York to pilot such a restriction in 2011 (Brownell and Ludwig, 2011) despite evidence that SNAP could be a good forum for the introduction of healthier diets.

SNAP authorities are reported to prefer an incentive, rather than regulatory, approach, and have launched a Healthy Incentives Pilot (HIP) to encourage fruit and vegetable consumption. Under HIP, SNAP participants received 30 cents for every SNAP dollar spent on targeted fruits and vegetables – this was credited back to their EBT card to be spent on any SNAP-eligible foods or drinks. HIP's recent preliminary evaluation revealed some promising early results, with HIP participants eating one fifth of a cup more fruits and vegetables a day than non-SNAP participants and 25% more than the control group within SNAP (USDA, 2013b).

Some researchers argue, however, that a regulatory approach could yield even better results. Basu et al. (2013a), for example, estimated that banning sugary drink purchases under SNAP would be expected to avert 510,000 diabetes person-years and 52,000 deaths from heart attacks and strokes over the next decade, saving $2,900 per quality-adjusted life-year saved. They also simulated that a tax on SNAP-purchased sugar-sweetened beverages of one cent per ounce would lower programme costs compared to the outright ban, but avert fewer chronic disease deaths.

A US poll in 2012 of 3,024 adults suggested that 69% of respondents supported restricting the purchase of sugary drinks under SNAP, while 82% favoured additional incentives for healthy food purchases. Restrictions on buying sweetened drinks were less popular amongst the 418 SNAP participants polled, although 54% backed the idea (Long et al., 2012).

Other sources: Aldhous, 2013

Most debate in OECD countries revolves around the feasibility and effectiveness of moderating prices to discourage consumption of high-risk foods, especially fat and sugar. For example:

> *'In July 2010, the Danish government increased taxes on a range of products (including ice cream, chocolate, sweets, and soft drinks – raising prices by 25%) and decreased taxes on sugar-free soft drinks. Finland had a sweets tax in 1999–2000, when the taxation rate was 60 cents per kilogram. The tax was reintroduced in January 2011. In January 2010, Romania proposed a fat tax on fast food, soft drinks, and sweets, with the objective of raising tax revenue for funding health programs, but the tax has not been implemented.*
>
> …

Outside of Europe, in the United States, so-called "twinkie taxes" [taxes on sweets, confectionary and sugary drinks] have been implemented in 30 states.' (Capacci et al., 2012)

Little is yet known about the effects of these European taxes, because, in large part, most experiences are too recent to have had time to show their full impact. In addition, tax rates are often so low that many consumers take little heed of the extra cost.

The US has a longer history in this area. Its experiences show quite a strong response in terms of reduced consumption as a result of taxes, plus the generation of considerable tax revenues that can be deployed in health programmes.

'For example, Arkansas raised $40 million annually from a tax of about 2 cents per 12-oz can of soft drink. In Maryland in 1992 the imposition of taxes on snack foods led to a reported $500, 000 drop in sales for Frito-Lay (the potato crisp maker). California introduced a snack food tax in 1991 where popped popcorn and Milky Way bars were taxed but unpopped popcorn and frozen Milky Way ice cream bars were exempt. An entire cake was tax-free but a slice taxable. This tax resulted in an estimated 10% drop in the sales of snack foods; price elasticity was estimated at –1.21, indicating that demand may be sensitive to small increases in the price of snack foods. Revenue generated from the tax was not significant, jobs were threatened and under pressure from the food industry the tax was repealed.' (Caraher and Cowburn, 2005)

Not surprisingly, taxes have faced opposition from politicians and from the food industry, and some proposals and schemes have been abandoned:

'California tried to raise taxes to finance programmes to fight obesity. In early 2002 California attempted to impose a levy of $0.21 per gallon of soda and $2 per gallon of concentrate. This 'soda tax' would have generated $342 million a year in revenues to be shared between schools that stopped selling soda on their campuses, the State Department of Health Services to promote nutrition and exercise, and hospitals/clinics/ trauma centres. The bill was amended several times before being defeated by the Senate Education Committee in spring 2002.' (Caraher and Cowburn, 2005)

There are few studies on the effectiveness of food taxes. Caraher and Cowburn (2005) found just two for the UK, both of them modelling studies that simulated what the impact of such taxes might be. One reported that adding VAT to full-fat dairy produce in the UK would save 1,000 lives a year. Another study focused on the distributional consequences in the UK, showing that poorer households would pay much more proportionally in tax because their food budgets took up so much of their spending. More widely for Europe, Capacci et al. (2012) reported on nine studies that model the likely impacts of taxes through estimated elasticities of demand: these suggest that taxes would indeed be an effective way to change consumption and diets.

Rules and regulations

In ***developing countries***, the main regulations affecting diet are those aiming to improve the consumption of micronutrients, with mandatory fortification of commonly-consumed foods such as processed staples and salt being a frequent measure. These are quite low cost and effective (Allen and Gillespie, 2001; Behrman et al., 2004), but will only have a strong effect where those who are nutritionally vulnerable buy foods that have been milled or otherwise processed.

The same sorts of regulations on fortification have long been used in ***OECD countries***. Current debates on rules and regulations revolve around controls on advertising, meals and the marketing of fast foods in or close to schools and hospitals. Most European countries have controls on advertising directed at children, as does the province of Quebec in Canada. However, it seems that not much is

known about the effectiveness of such measures. Evaluations are not strong, as they tend to measure before and after these initiatives with no counter-factual; and they often register only intermediate outcomes, such as changed awareness and intentions rather than actual consumption and impacts on health (Capacci et al., 2012).

The regulation of meals in schools is a popular measure among health professionals, but the impact of such schemes has not been evaluated sufficiently. Pupils may eat more healthily in school, but little is known about potential compensatory eating beyond the school. Proposals include those to limit the availability of high-risk sugary drinks and snacks rich in fat, salt and sugar in schools and hospitals; as well as to restrict the setting up of fast-food outlets close to school gates, as mentioned earlier.

More drastic measures would impose limits on food processors using very high risk foods, such as trans-fatty acids, which have proved useful in food manufacturing but are considered to carry high risks related to cardio-vascular disease. Denmark introduced severe limits to the use of trans-fatty acids in 2004, with considerable reductions reported in their consumption and reductions in heart disease (Box 6). At least three other countries have banned the use of trans-fats in food processing completely: Austria, Iceland and Switzerland.

Other countries, such as the UK, have preferred to work with industry to limit salt and trans-fats in processed foods. Notable declines in consumption have been seen, but it is not clear whether this is the result of these actions or of consumers adopting healthier options (Capacci et al., 2012).

The ultimate measure in the control of diet is simply to ration access to food. Centrally planned economies rationed food not by price (as in market economies), but often by queuing and by the administrative rationing of entitlements to buy foods. These applied mainly to complementary foods that were sometimes in short supply in such economies.

During the Second World War, the UK adopted a comprehensive programme of food rationing, given the country's dependence on imported foods that were threatened by attacks on merchant shipping (Box 7). This became an astonishing social experiment, as nutritionists were engaged to devise a nutritious diet based on the supplies available, while home economists were drafted to prepare recipes that would transform the official rations into tasty dishes. Indeed, it is reported that the nutrition of the British actually improved during the War. Nevertheless, rationing was not popular, and while it took years to end rationing once the War was over, the system was abolished as soon as it was feasible to do so.

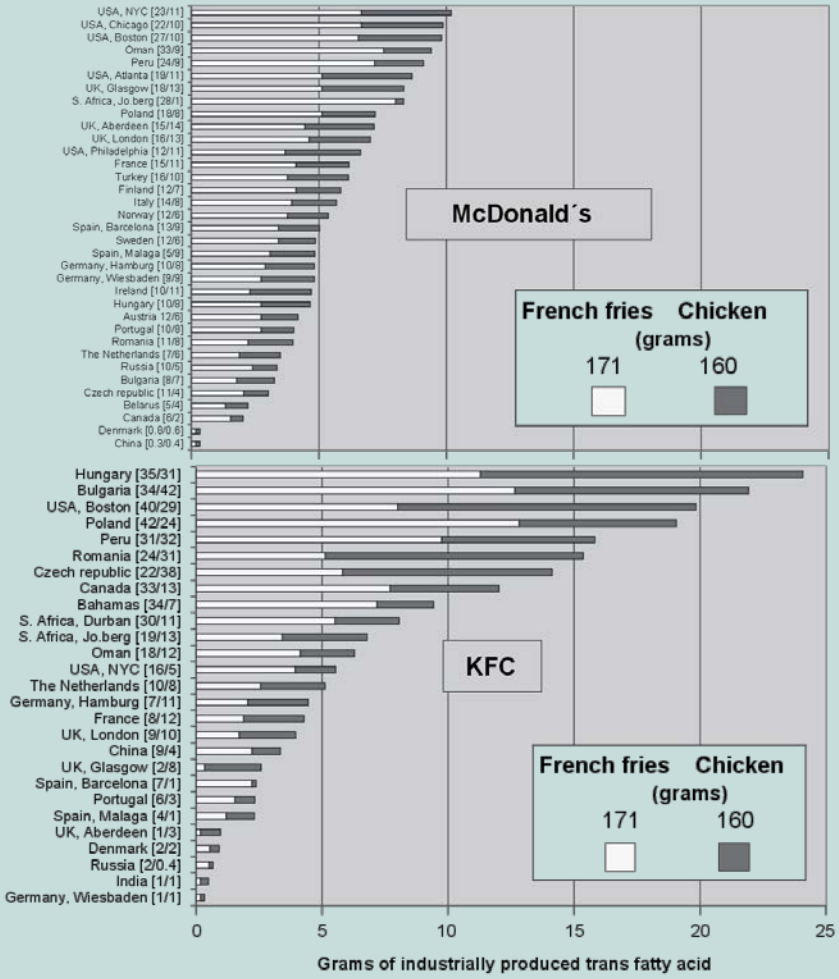
Box 6: Denmark's limits on trans-fatty acids

In 2004, Denmark imposed limits on industrially-produced trans-fatty acids (IP-TFA) in foods to no more than 2% of their total fat (Stender et al., 2006). This was achieved without affecting the availability, price or quality of foods that once contained large amounts of IP-TFA.

Figure 3.2 shows that Denmark now ranks very low in grams of trans-fat served in Danish McDonald's and Kentucky Fried Chicken (KFC) when compared with their counterparts across the world:

'Various public health organizations, including the World Health Organization, have recommended reducing the consumption of IP-TFA, and efforts have been made in several countries to comply, through the mandatory TFA labelling of prepackaged food, societal pressure and industrial initiatives to lower the content of IP-TFA in foods. Yet still, high concentrations of IP-TFA are found in popular foods in several countries including Norway and Sweden. This indicates that millions of people currently have intakes of IP-TFA that increase their risk of coronary heart disease. The Danish experience demonstrates that this risk can be eliminated.' (Stender et al., 2006)

Figure 3.2 Grams of trans-fats per large serving of McDonald's and KFC chicken and chips in Denmark and selected countries



Source: Figure 1 in Stender et al. (2006).

Note: Values in brackets are % trans-fatty acids of total fat in french fries and chicken, respectively.

Box 7 UK food rationing in World War Two

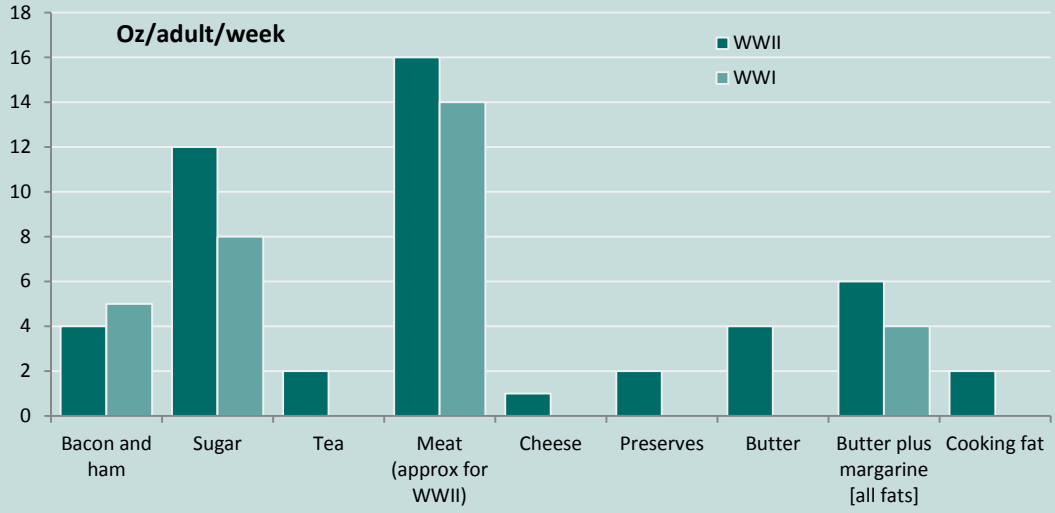
Rationing during WWII in the UK provides a highly unusual example of a relatively modern, democratic country instituting an extreme form of control over the diets of the majority of its population.

Before 1939, the UK was a poorer and less equal society than it is today. The food that people could afford varied. The diet of the very poor, for example, tended to be limited to pulses, white flour, white and brown bread, margarine and suet, pasta, rice, sago, tapioca and potatoes with some dates, currants and figs, sugar, treacle, cheap cuts of mutton, cheese from New Zealand and bacon. Those who were less-poor could afford some butter, cornflour, parsnips, raisins, imported mutton and lamb, cheaper cuts of beef, milk, herrings, sweet biscuits, and some pork. Only those people who were escaping poverty could afford British meat, more vegetables, fruit, fish, and eggs. The diet of the middle-class was based on bread, butter, milk, fish, meat, eggs, vegetables, fruit, game and poultry.

The Great War of 1914-1918 set a precedent for rationing. With submarine attacks leading to food shortages in the UK by December 1916, fats, sugar, meat, and bacon were rationed from 1918 until 1920. Having learnt from the food shortages during the Great War, the UK was keen to avoid similar hardships during WWII.

Rationed foodstuffs included bacon and ham, sugar, tea, meat, cheese (agricultural workers received a higher cheese ration), preserves, butter, margarine, and cooking fat. Figure 3.3 compares some basic rationing levels over the two world wars.

Figure 3.3 Average weekly rations for UK adults during WWII compared to WWI, ounces



Source: Data from Knight, 2007.

Note: Meat ration is approximate for WWII as it was determined by value rather than weight. Explanation in square brackets refers to WWI definition.

Certain foods were seen as important for good moral, and while major public efforts ensured a sufficient supply of basic starches in sufficient supply, higher-value foodstuffs, especially those that needed to be imported, had to be rationed so that low supply and high demand would not put them beyond the reach of the poorer segments of the population. Though far from essential for health, therefore, reasonable quantities of sugar were included in rations, with sugar in a cup of tea seen as restorative and good for the spirits, and important in a time of war as part of the British culture. Eggs and fish came close to being rationed but were not, although eggs were often in short supply. Dried eggs were imported from America as a way to ensure that people in towns, who did not keep hens, had access to this nutritious source of protein, vitamins and minerals that would otherwise have been unavailable.

Leading nutritionists employed by the Ministry of Food at the time were also keen to use the opportunity to improve the nutrition of pregnant women and children, who often had poorer nutrition if from poorer backgrounds. So the nutritional needs of pregnant women, babies, and children were prioritised.

Food rationing was accompanied by a big public information campaign, with leaflets, posters, and radio programmes about healthier eating, promoting unusual new products such as canned meats, or less-used traditional foods like herrings or cod, and about reducing waste.

WWII rationing by the Ministry of Food succeeded in feeding the population a nutritionally balanced diet at a time when supplies were scarce. Taken together, limiting the intake of ‘unhealthy’ foods like animal fat and sugar, the levelling effect of rations that improved nutrition for people on low incomes, and nutritional education, meant that people’s nutrition actually improved, with key indicators such as infant mortality falling during the course of the War.

Source: Knight (2007).

The politics of diet policy

Diet policy is not generally popular. The choice of food is considered a personal freedom in much of the industrialised world, and one in which policy-makers are loathe to interfere, despite strong evidence that many people choose unhealthy diets – albeit under many influences – and place premature or avoidable burdens on health providers (see McCarthy, 2004; Aggarwal et al., 2012).

The apparent apathy and antipathy to diet policy may stem, in part, from different schools of thought on diet, with a significant difference between those who see diet as a matter for individual behaviour and choice; and those who see the food environment – the costs of food, ease of physical access, etc. – as a heavy constraint on choice (Caraher and Cowburn, 2005). The former school favours a light touch, such as public education, while the latter sees an argument for deploying stronger public measures to align individual choices with social optima.

Attitudes to diet policy in Europe have been studied by González Zapata et al. (2010) through carefully structured interviews with 189 informants from 21 stakeholder groups in nine EU countries. They were asked for their criteria for evaluating diet policy that aimed to reduce obesity and associated illness and for their rating of 20 options. Public education options were, in general, the most favoured, while the economic incentives of subsidies and taxes were the least liked. Not surprisingly, the strongest opposition to economic measures came from agricultural and food industry representatives, while they had the greatest support from nutrition and health specialists.

Diet policies, and in particular those directed to reducing the consumption of fat, salt and sugar, may be compared to policies to control smoking and alcohol. Significant progress has been made on these through a combination of (severe) restrictions on advertising, control of sales, and, in the case of tobacco, very heavy tax and controls on smoking in public. It seems, however, that there is little appetite to repeat these experiences with high-risk foods, despite studies such as that of Cecchini et al. (2010) that model large gains in reduced health costs, less disability, the avoidance of early death and the higher productivity likely to result from reduced intakes of fat, salt and sugar.

Combining policies

For clarity, it is convenient to try and assess policies individually. In practice, however, it is recognised that isolated measures – especially when they are mild in their degree – may have a limited impact, whereas a battery of small measures may have a much larger effect.

Scandinavian countries are unusual in having debates on diet, nutrition and diet going back 50 years or more, with a wide range of measures being considered. National strategies have emerged that combine several elements (Kjærnes, 2003), with some signs of progress. And this in a region where traditional diets favoured the heavy consumption of fats where possible.

Box 8 recounts Norway’s experience that has had some success, although obesity rates rose until the most recent statistics in the early 2000s.

Box 8: Linked macro-economic, agricultural, health and nutrition policy in Norway

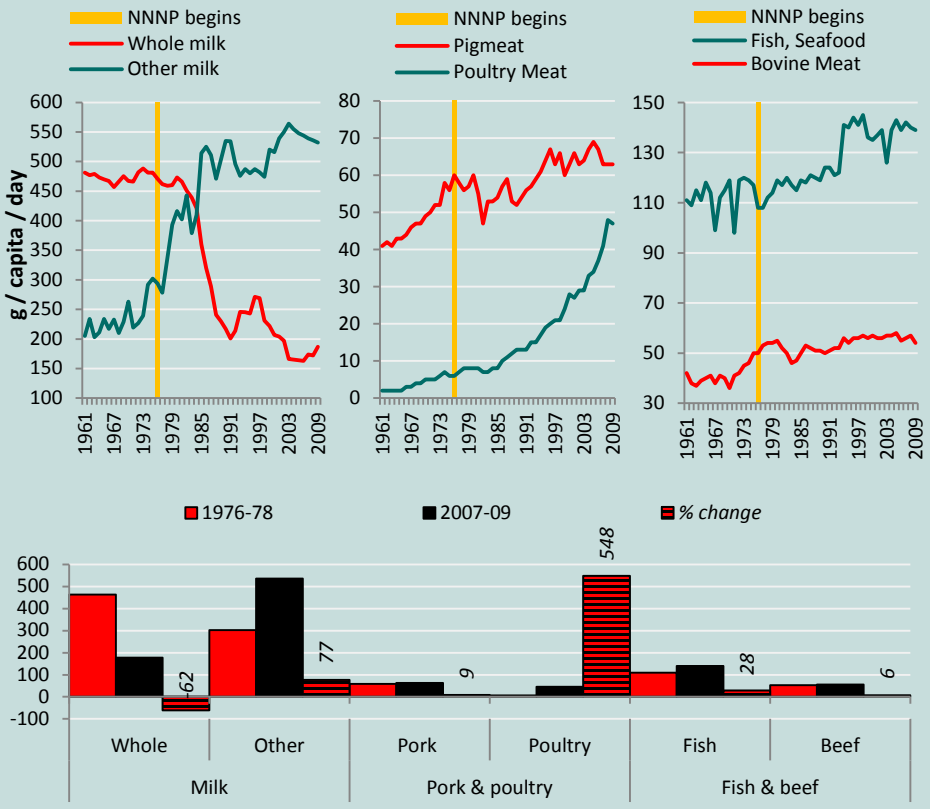
Norway developed the Norwegian National Nutrition Policy (NNNP) in 1976 to link economic and agricultural policy with health and nutrition. Measures under NNNP included: stimulating research on breeding cows for lower-fat milk; denying consumer-price subsidies when sugar import prices surged in the mid-1970s; increasing consumer subsidies for skimmed milk above those for whole milk, for poultry more than for pork, and for fish more than for beef; and implementing producer subsidies to favour fish over beef production (Popkin and Ng, 2006).

Dramatic results were attributed to these policies:

> *' … a large change in the proportion of whole and reduced-fat milk, rapid increases in the consumption of poultry, and changes in the amount of edible fat and the proportion of margarine and light margarine. Norway has most markedly reduced the proportion of energy obtained from animal fats, from 29 percent in 1961 to 23 percent in 1988. The reductions in total fat of about 6 percentage points (from 41 percent to 35 percent) was observed between 1975 and 1989, with equally large declines in saturated fat [Milio, 1991]. (Popkin and Ng, 2006)*

Whole-milk consumption has decreased sharply since 1976, while other milk consumption has increased; fish and seafood consumption more than that of beef; and poultry consumption has soared compared with that of pork (Figure 3.4).

Figure 3.4 Animal-source foods supplied, Norway, 1961 to 2009



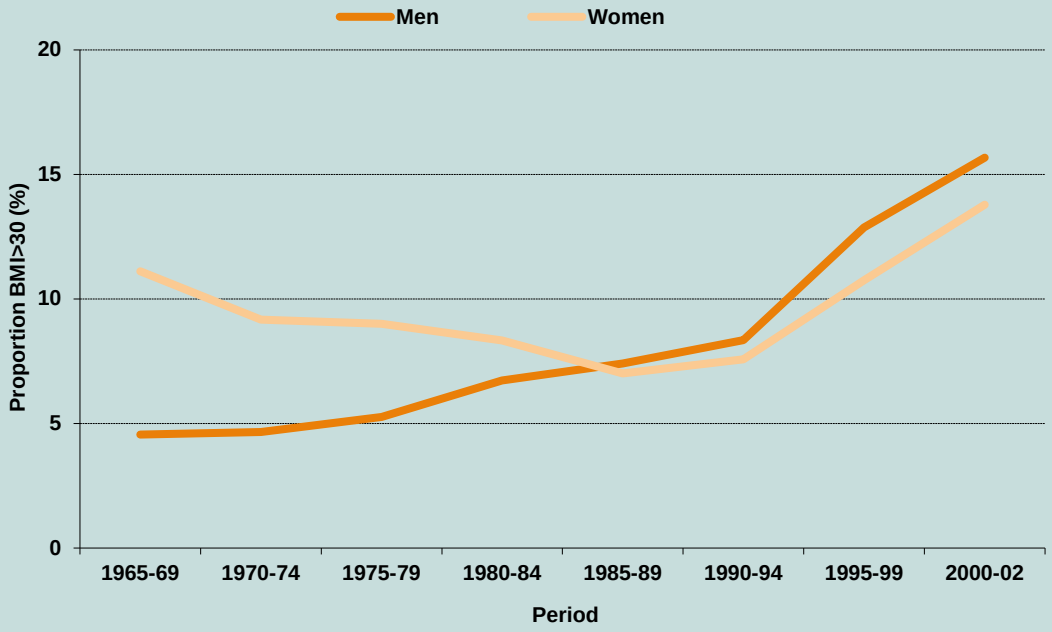
Source: FAOSTAT.

Ithough these changes may seem positive, per capita fat consumption in Norway was and is still well above the global average (see Figures in Appendix 4) as well as the amount recommended in a healthy diet. Per-capita fat supply in Norway has exceeded 150 g/cap/day for the past 50

years, and actually increased slightly over the period under review, while the average adult needs about 50 to 100 grams of fat a day.

Not surprisingly, obesity is rising in Norway (Figure 3.5).

Figure 3.5 Proportion of adults in Norway, aged 40-44, with obesity; BMI 30kg/m^2 and higher



Source: Engeland (2003) reported on fact sheet from the Norwegian Institute for Public Health (http://www.fhi.no).

Interestingly, Bere and Brug (2008) asked whether it is possible to configure a healthy diet for Norwegians based on traditional local foods. Their answer was to emphasise local foods including native berries; cabbage; native fish and other seafood; wild and pasture-fed livestock; rapeseed oil; and the cereals of oats, barley and rye. But they admit that:

> *'Identifying which foods could be included in a health promoting regionally defined diet is only a first step. The next and much more complicated challenge is how to get people to indeed eat these foods instead of the foods they have grown accustomed to. In affluent countries, most people can generally choose what, when and how much they eat. Therefore, a major challenge is to get people to choose to eat in accordance with regional diets such as the Nordic example.' (Bere and Brug, 2008)*

Conclusions on policy

Several issues emerge strongly from this review of public policy for diet, even in the absence of imperfect evidence.

- Policies to improve diets have been rather timid, with some significant exceptions such as the public distribution system of India or rationing in wartime UK. Politicians are fearful of meddling with diets and alienating farming and food industry interests. It seems that this reflects public opinion, with many stakeholders seeing food choices as matters of personal freedom.

- As a result, most policies have had a limited impact. Within the major categories of policies, it seems that regulations and price incentives have the strongest impact, but these are precisely the policies that attract most opposition.

- The scientific consensus that sees some aspects of diets in OECD countries as significant contributory factors to some cancers, cardio-vascular disease and diabetes has cut little ice with public opinion and political leadership.

- This stands in marked contrast to the concerted public actions that have been taken to limit smoking in OECD countries.

We do not know, therefore, how effective a determined drive to reduce consumption of calories and to reduce significantly the consumption of fat, salt and sugar in OECD countries might be. It has not been attempted anywhere as yet.

This is not to conclude that diet policy must be hesitant and timid, even if that is, apparently, the public mood. When taking action to limit tobacco smoking, governments often led the way, given the strong evidence from medical studies showing the harm caused by smoking. Although diet is a more diverse issue than smoking, there may be scope for governments to take more incremental measures, perhaps in combination that may pave the way for public acceptance that something needs to be done, if future health costs are to be contained.

4 Projections of future diets

How may diets evolve over the next few decades, and what may be the consequences for demand for food — and hence on cost of food? Three recent models were found that looked at one or more of these questions: those from the Food and Agriculture Organization (FAO), the Centre de coopération internationale en recherche agronomique pour le développement at the Institut national de la recherche agronomique (INRA-CIRAD) and the International Food Policy Research Institute (IFPRI).

4.1 FAO

Updating previous work at FAO, Alexandratos and Bruinsma (2012), predict aggregate agricultural production (excluding forestry and fisheries) and food consumption to 2050. From a base period of 2005-2007, they forecast what agriculture needs to produce by 2050 to meet demand and what this will entail in terms of overall agricultural growth, trade, calorie undernourishment, land and yield changes (see Appendix 7 for more detail).

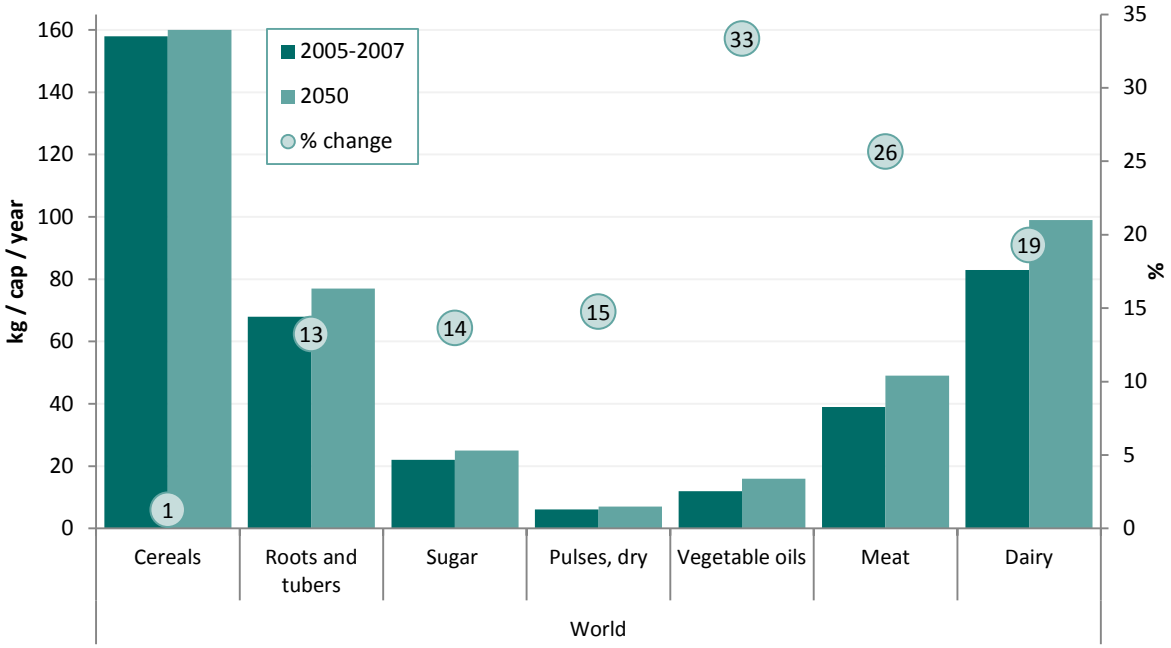
Demand in the model increases as (UN-projected) populations and (World Bank-projected) incomes rise, with changes in patterns of demand based on consumption trends (using FAO statistics). There are implications for trade and the factors of production including land, water and fertiliser.[24] Expert opinions are used to adjust projections by country and commodity, rather than extrapolating solely from existing trends.

Alternative scenarios are not considered, though high degrees of uncertainty exist around many of the determinants, including the likely demand for biofuel feedstock or livestock feed grain. The study does not take into account the uncertain future effects of climate change.

On diet, Alexandratos and Bruinsma project global and regional consumption, in calories and in kilograms, per person for food groups in 2030 and 2050 (Figure 4.1 provides the 2050 projections for world averages). The largest proportional increases expected per person are for vegetable oils (33%), meat (26%) and dairy (19%). Cereals consumption per capita is likely to rise by only 1%. Richer parts of the world are expected to reach saturation on per-capita consumption of basic food groups, with little growth in quantity after the 2030s and 2040s.

[24] With data from FAO and for land, from a study, Global Agro-ecological Zones (GAEZ) by FAO and IIASA.

Figure 4.1 Food supply projected by type of food, kg/cap/year, 2005-2007 (average) to 2050



Source: With data from Table 2.5 in Alexandratos and Bruinsma (2012).

Notes: Cereals are for food use only; sugar is raw-sugar equivalent; vegetable oils includes vegetable oils, oilseeds and products in oil equivalent; meat is carcass weight; dairy is milk equivalent, excluding butter.

Given slowing population growth, with some parts of the world expected to have fewer people by 2050, and the saturation of food consumption in most high-income countries, agricultural production will not need to grow as quickly as in the past 50 years.

Animal feed demand is also modelled. This will, increasingly, drive overall demand for coarse grains in the developing world – maize, plus sorghum barley, millet, oats, etc. While feed use accounted for 42% of global coarse grain use in 2012, it is set to increase to some 56% of coarse grain use by 2050.

A key uncertainty in animal feed demand is the current and projected level of meat consumption in China. With such a large population, even small changes in Chinese per-capita consumption can have profound effects on global balances. China reported average meat consumption of 54 kg/cap/year in 2005-2007, but some doubt that its consumption could already be so large, given the estimated availability of feed for the implied livestock population (Aubert, 2008). If China's actual meat consumption were, say, 70% of the official figure, as Aubert (2008) believes, then to reach the levels projected for 2050 of 71 kg/cap/year, growth will have to larger than modelled. Given China's size, the implications for feed grains matter: a 30% over-estimate implies 6.9 kg/cap/year more that would need to be produced, making an extra 36 million tonnes of feed grain for an estimated population of roughly 1.3 billion by 2050, assuming an average feed conversion ratio of four units of grain to one of meat. This would mean that feed grain production across the world would need to grow at 0.97% a year, instead of 0.90% a year, from 2005-2007 to 2050.

4.2 INRA-CIRAD: Agrimonde

Agrimonde's Foresight project, a collaboration of INRA and CIRAD, looks at more equitable[25] scenarios of feeding the world in 2050 (Paillard et al., 2011). It explores the implications of sustainable development in economic, social, and environmental dimensions to satisfy three objectives: meet growing demand, allow for income growth from agriculture in rural areas of the developing world, and use environmentally-friendly agriculture.

Two scenarios are modelled; Agrimonde 'Global Orchestration' (GO) – a scenario devised under the Millennium Ecosystem Assessment project (see Millennium Ecosystem Assessment, 2005) and Agrimonde 1.

Both scenarios make the same assumptions about demographic growth and migration and split the globe into the same major regions: Middle East and North Africa (MENA); sub-Saharan Africa (SSA); Latin America (LAC); Asia; the former Soviet Union (FSU); and OECD. Each scenario first assesses the capacity of each major region to meet its own food requirements in 2050 before considering inter-regional trade. Neither scenario incorporates the uncertainties of future climate change.

Agrimonde GO is a trend-based projection in terms of food-calorie consumption evolution. The GO scenario imagines a future world with a well-connected global society, and well-developed markets. The GO world cooperates to improve the social and economic well-being of all people, as well as to protect and improve global public goods and services (such as public education, health, and infrastructure). Externalities created in the development of markets are internalised, and the state regulates where appropriate, but not excessively. Under the GO scenario, responses to environmental problems that threaten human welfare, such as pollution, erosion and climate change, are not dealt with proactively, but only after they become apparent. GO assumes that technological responses will meet major environmental challenges. However, this scenario means that the risks from ecological surprises are high, as a result of the reactive rather than proactive nature of people's behaviour.

Under Agrimonde GO, current trends continue in the production and use of food in a world where the priority is economic growth and the material well-being of current generations. Projected economic growth drives consumption in all regions of the world up to a mean availability of 3,590 kcal/cap/day by 2050 – ranging from close to 3,000 kcal/cap/day in SSA to around 4,100 kcal/cap/day in OECD countries.[26]

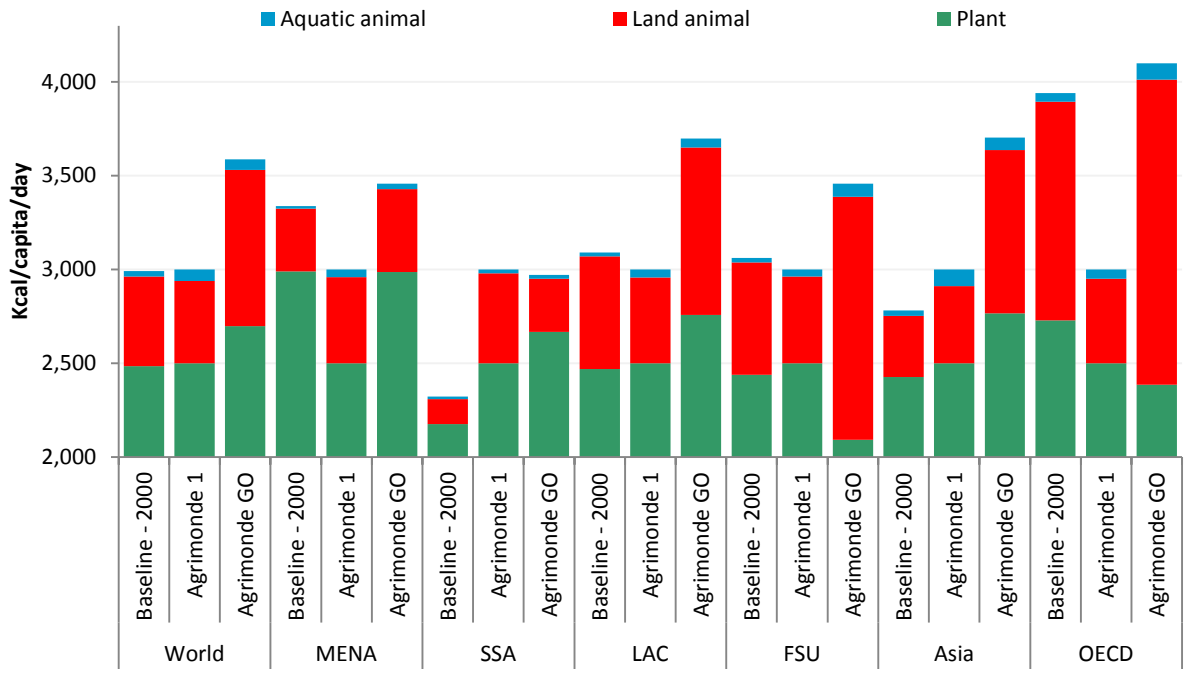
Agrimonde 1 involves stronger assumptions: a world in 2050 that has created sustainable food systems and reduced inequalities in access to food, with ecosystems protected.

The objective of Agrimonde 1 is to achieve an average 3,000 kcal/cap/day for every region, with at least 500 kcal from animal sources. This means less consumption and waste in developed countries and increases in food consumption in many developing countries. Figure 4.2 shows the kilocalorie distribution in 2050 under the two models.

[25] In 2003 for instance, OECD countries, with 16% of the global population, had 30% of global plant-calorie consumption, compared to sub-Saharan Africa with 11% of the world population and only 7% of global plant-calorie consumption (data from Table 5.3 in Paillard et al., 2011).

[26] This compares to world global average availability growing from around 2,500 kcal/cap/day in 1961 to 3,000 kcal/cap/day in 2003

Figure 4.2 Food availability in 2000 and projected to 2050 under two Agrimonde scenarios, by plant and animal sources



Source: Data from Table 5.2 in Palliard et al. (2011).

Both Agrimonde models look at diet only in energy terms, although they assume more balanced diets in 2050 than at present.

To achieve the food production projected, Agrimonde GO requires economic growth that is higher than the past averages seen in some regions. Here, growth is the result of trade liberalisation, extensive economic cooperation and the rapid diffusion of new technologies. In addition, in Agrimonde 1, global economic growth from 2000 to 2050 is driven by growth in developing economies that has strong support from the agricultural and agri-food sectors. The rural to urban exodus has slowed as a result of economic growth in rural areas. Ecological intensification practices have spread, and an infrastructure of regional planning and supply chains has been put in place in developing economies to deal with transport, storage, industrial processing, health, education, and training. Necessary investments have been made possible by improved income in rural areas. This is the result of the development of rural employment, better distribution of added value through supply chains, and the pooling of resources. Public transfers and international aid for development also play a critical role.

The reduced animal-product availability in Agrimonde 1 in OECD countries, especially from grazing animals, and the limited increase in other regions, stems from the environmental and energy impact of livestock production. The availability of food from fresh-water sources increases very little because these are already under such high pressure.

4.3 IFPRI IMPACT model

IFPRI (Msangi and Rosegrant, 2011) have used their partial equilibrium model of world agriculture and food markets, IMPACT (International Model for Policy analysis of Agricultural Commodities and

Trade)[27] to address most of the questions of interest: above all, how varying levels of meat consumption will affect future demands for feed grains and prices of food. For the period 2000 to 2030, the model examines how changing consumption patterns will affect the world's agricultural economy, as well the implications for nutrition. Expected increases in incomes and populations are the main drivers modelled. Again, climate change is not taken into account.

Crop production is based on estimated areas and yield, which are themselves based on prices of outputs and inputs, plus trend factors, less reductions owing to water stress. Feed demand is also projected for different regions, as coarse-grain demand in tonnes.

For diets, the Msangi and Rosegrant model projects total calorie availability, as well as consumption of food groups (cereals, meats, fruits and vegetables) in kilograms.

The IMPACT model computes world prices as well as physical quantities for the main commodities: cereals, animal products, potatoes, cassava, and meal, as well as some pulses, fruits, and vegetables.

For nutrition, they project rates of children under five years who are underweight, based on estimates computed using the econometric estimate of Smith and Haddad (2000).

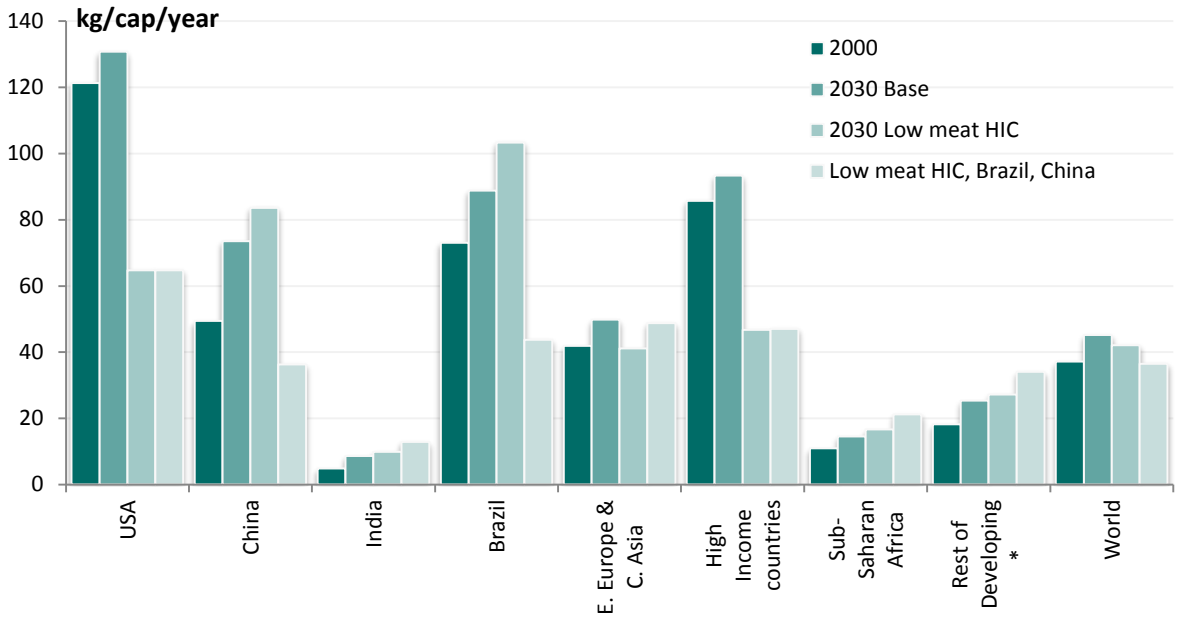
Four scenarios are used to explore the implications of different levels of meat consumption, as follows:

1. A'business as usual' scenario to 2030
2. A scenario in which high-income countries (HICs) have half the meat consumption expected by 2015, reflecting a shift in food preferences to follow more environmentally friendly diets
3. A scenario in which HIC plus Brazil and China have half the level of meat consumption forecast
4. A similar scenario but with 20% higher consumption of fruit, vegetables and pulses to compensate for less meat consumption.

In the base-run of the model, world meat consumption rises, with more eaten in all regions, but with notable increases for Brazil, China and other parts of the developing world (Figure 4.3). The average for the world as a whole rises from 37 to 45 kg/cap/year. If, however, HICs cut their meat consumption in half, then these increases are mitigated, but the world average still rises to 42 kg/cap/year because lower HIC consumption reduces the cost of meat in other regions and increases their consumption. When, however, Brazil and China also cut their projected 2030 per person meat consumption to half its level, then the average consumption in the world remains almost unchanged from 2000 to 2030 since other developing countries increase their consumption.

[27] IMPACT is a partial equilibrium model for crop and livestock, including cereals, soybeans, roots and tubers, meats, milk, eggs, oilseeds, oilcakes/meals, sugar/sweeteners and fruits and vegetables. IMPACT includes assumptions about population growth and demographic changes. Supply, demand and prices are determined for given regions. Surpluses clear through trade. (Rosegrant et al, 2005)

Figure 4.3 Projected levels of meat consumption per person, 2030, by region



Source: Compiled from data in Msangi and Rosegrant (2011), Table 1.

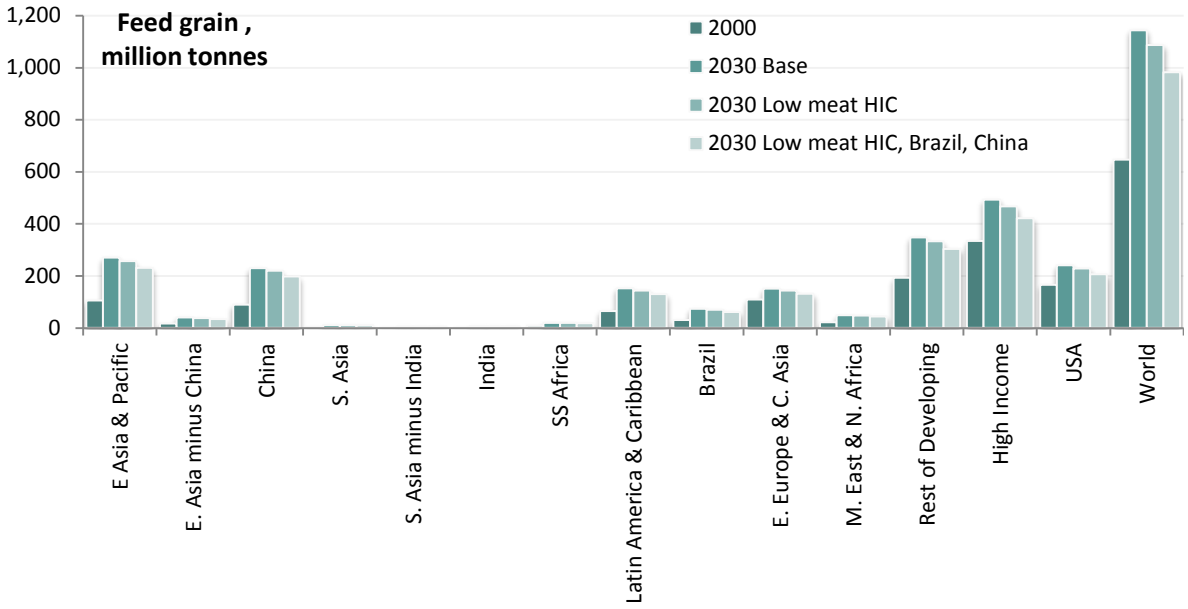
It can readily be appreciated, then, that world meat consumption is unlikely to fall to 2030: even with scarcely believable assumptions for HICs plus Brazil and China, there is so much pent-up demand in developing countries that total production will tend to rise. It is worth noting that even if there were drastic reductions in meat eating in HICs, Brazil and China, this does not produce a world of equitable access to meat: the US would still see consumers eating more than 60 kg/cap/year, while those in Africa would only consume an average of 21 kg/cap/year.

How big a difference do differing levels of meat consumption make, then, to the demand for feed grain for livestock, and to prices for grains, meats and other foods? The basic run of the model sees feed-grain production rising steeply from 646 million tonnes in 2000 to 1,144 million tonnes in 2030, an increase of 77% (Figure 4.4). Very large proportionate rises are seen for China and other parts of the developing world. Much of future meat production has to come from feeding cattle with grains, rather than production from pasture. The two lower-meat scenarios reduce this increase, saving production of feed grain by 56 million and 161 million tonnes to generate modest reductions of 5% and 14% respectively. In a world likely to be increasingly constrained in producing more food, such savings are worthwhile, but they are not that great.

The different scenarios are reflected in world prices for different foods (Figure 4.5). In the base scenario, there are modest increases in the prices of most grains and for beef, but not for poultry, the price of which actually falls to 2030. The two low-meat scenarios make a big difference to the prices of beef and poultry: chicken prices fall to less than half what they might otherwise be. The effect on grain prices, however, is remarkably slight. It is evident that saving on feed grains makes almost no difference to the expected prices of grain, whether for feed or human consumption.[28]

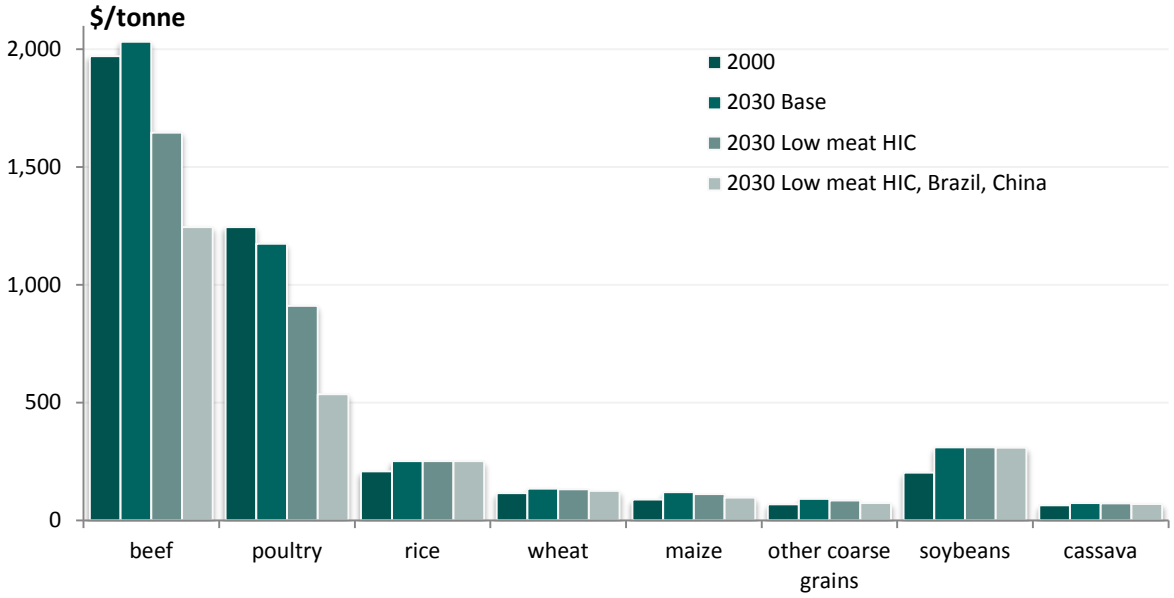
[28] It is not surprising, therefore, that the gains for child malnutrition in the developing world are limited as well.

Figure 4.4 Projected levels of feed grain production, 2030, by region



Source: Compiled from data in Msangi and Rosegrant (2011), Table 3.

Figure 4.5 World prices, selected foods, 2030



Source: Compiled from data in Msangi and Rosegrant (2011), Table 2.

In conclusion, these three models ask rather different questions and deploy different means to arrive at their answers. The FAO model looks primarily at needs for future agricultural production, based largely on a most likely scenario with no major policy interventions. It sees substantial increases in animal feeds being needed for 2050 – increases that are feasible, given that the necessary growth rates of production are under 1% a year. This model does look at the impacts on costs of production. Agrimonde also sets aside the issue of costs, but in projecting future diets, it does set out alternative

scenarios to see whether it is possible to have a future agriculture that feeds people equitably and healthily and that respects environmental limits. Fortunately the answer is yes: all three goals can be achieved.

The IFPRI model is the one that comes very close to addressing the questions set in this paper, as it looks at both alternative scenarios expressed in varying consumption of meat, as well as exploring the consequences for food prices. The rather surprising result is that varying future levels of meat consumption make big differences to the amount of meat produced and to meat prices; but have only modest effects on the amount of feed grain required, and next to no effect on staple grain prices. This is all the more surprising, given that the IFPRI low meat scenarios involve strong, 'what if?' scenarios. Can we really ever expect consumers in high-income countries to cut their average meat consumption by half of what it would have been? And can we really expect Brazilian and Chinese consumers to follow suit?

The implications of these thought experiments will be spelled out in the final chapter.

5 Conclusions and discussion

The following key conclusions emerge from this review.

1. Over the past half century, the availability of food has increased across the world and across regions. Diets have changed correspondingly, with increased consumption of food energy, above all from animal foods, fat and sugar. Rising incomes appear to be a prime driver of national diets, so much so that the concept of a dietary transition is taken as template for what may be expected as countries develop, with higher incomes, more urban living and more sedentary lives. In this transition, diets evolve from being rich in cereals, roots and tubers, to those that have greater proportions of animal produce, fruit and vegetables, fat and sugar, while an epidemiological crisis of non-communicable disease emerges.

2. Although our review confirms this pattern to a considerable degree, diets differ significantly across countries and are influenced not only by income, but also by the costs of different foods; by preferences formed by culture, religion, location and modified by advertising and information from other countries; by social changes in work and gender roles; by changing structures of food production, processing and retailing; and by public policy. Some see forces of globalisation as dominating the evolution of diets, or more specifically the increasing trade in food, foreign direct investment in the food chain, and flows of information through advertising and the media. Yet a simple test for any convergence in the eating of animal foods across countries failed to confirm this influence. Instead, heterogeneity across countries may be increasing. In the search for a grand theory, the extent of localised differences may be understated.

3. Policies to improve diets have been rather timid, with some significant exceptions, such as the public distribution system of India or rationing in wartime UK. Politicians seem afraid to meddle with diets and thereby alienate consumers as well as farming and food industry interests. It seems that this reflects public opinion, with many stakeholders seeing food choices as a matter of personal freedom. As a result, the impacts of most of the policies seen to date have been limited.

4. Projections for diets, for both the world and its main regions, that are based on differing levels of meat consumption, include some strong assumptions about what might happen if high income and emerging economies were to adopt much lower consumption of meat. These varied projections find surprisingly little difference in the amount of feed grain required in 2030, and next to no difference on staple grain prices, even if there are big differences in the amount of meat produced and in meat prices.

What can we make of this, and its implications for public policy and especially for future agricultures and food costs? Three key implications emerge.

First, diets and their influences are more varied than some may imagine. Yes, the combined forces of economic growth, rising incomes, urbanisation and globalisation are powerful, but we should not underestimate the extent of local variation. Bear in mind that in it has not been possible in this review – for lack of readily available data and time – to look at diets at a level more detailed than national average consumption. It is known that even within national templates there are wide variations by

income groups, by regions within countries, and by other social variables such as vegetarianism and culinary traditions. So, getting closer to the grain of reality would reinforce this message of variety and the limits to which growth and globalisation may lead to homogenous diets.

The implications are two-fold: that globalisation will not, in the medium term place massive restrictions on the scope for policy action; and that policy needs to start where people are at present, in terms of their diverse preferences and traditions. Trajectories are not pre-ordained; there is scope to influence the evolution of diet to get better outcomes for health and agriculture.

Second, IFPRI's modelling reveals some surprising results. Indeed, one of the reasons we run model is to check for surprises. Meat consumption that seemed *a priori* to matter immensely for future agricultures in terms of demand for feed grains and, by extension, cost of many foods, turns out to be less important in this regard than imagined. At the margin, of course, lower meat intakes in high income and emerging economies would make it easier and cheaper to grow food in the future. It would almost certainly lead to a fairer world in that it would allow relatively low meat prices for low-income cohorts in developing countries.

This implies that lower meat consumption does not matter quite so much from an agricultural point of view, nor from our original concern – the cost of staple foods. But that does not mean that meat consumption, and the consumption of dairy and some fish, does not have public importance. It means, in fact, that the more important public concerns probably lie with better health. Studies such as that of Cecchini et al. (2010) show large benefit-to-cost ratios from measures to influence people to adopt healthier diets. The prime concern of such measures relates to the intakes of fibre and fat, which many be linked only partly to animal-produce consumption, but they are certainly linked. There may also be good reasons to limit the livestock economy on environmental grounds, not least to restrict emissions of greenhouse gases. Unfortunately we did not have the time to assess the growing literature on this consequence of diet.

Third, we can see a paradox of public policy. There is little appetite amongst the public and their leaders in high-income countries to take strong measures to influence future diets. Most people hate to see regulation of their access to favoured foods, see taxation of unhealthy foods and ingredients as onerous and unfair, and acquiesce only in response to public information and education. Couple this with lobbying from food industries, and the political will to affect diets withers.

Yet against this we must set the growing scientific consensus that sees some aspects of diets in OECD countries – and above all excessive consumption of fat, salt and sugar – as significant contributory factors to some cancers, cardio-vascular disease and diabetes. Tentative models of the benefits of better diets on public health show many advantages. The lack of will to act on diet stands in marked contrast to the concerted – and largely effective – public actions that have been taken to limit smoking in OECD countries. It seems that regulation and taxation are the most effective policies for diet, but these are precisely the policies that are least palatable to both the public and politicians.

In fact, diet policies have been so timid to date that we have little evidence of how effective a determined drive to reduce consumption of calories overall and consumption of fat, salt and sugar in particular might be in OECD countries. This has never been attempted, with the rare exception of Britain's wartime rationing, which stands out as an unusual natural experiment, and one that the British public were delighted to abandon once supplies had been restored after the Second World War.

Current action on diet may be hesitant and timid, but that does not mean that governments should always be so cautious: the public-health case for influencing diet is strong in high-income countries. At some point in the future there may well be international debate over meat consumption and what fair shares of meat can be produced at relatively low cost and within the limits of environmental sustainability and greenhouse-gas emissions. Policy may be able to proceed incrementally, both in ambition and instrument, using combinations to get the best effect.

A final comment (and paradox): interest in diet has never been stronger in high-income countries as we obsess about our waistlines, worry about the social impacts of the marketing strategies of (very) large food retail chains, and enthuse over the culinary art and tradition shown in countless television programmes. Scientifically, a plethora of papers have been drafted in the past 10 years that ponder the rise of obesity worldwide and its implications.

It seems, then, that it is only a matter of time before a turning point arrives at which there is more appetite for stronger and effective measures to influence diets. When that time comes, we will need the evidence – provided in a very preliminary way by this review – on the main problems of emerging diets, and which policies (and combinations of policies) will be most effective in addressing the emerging challenges.

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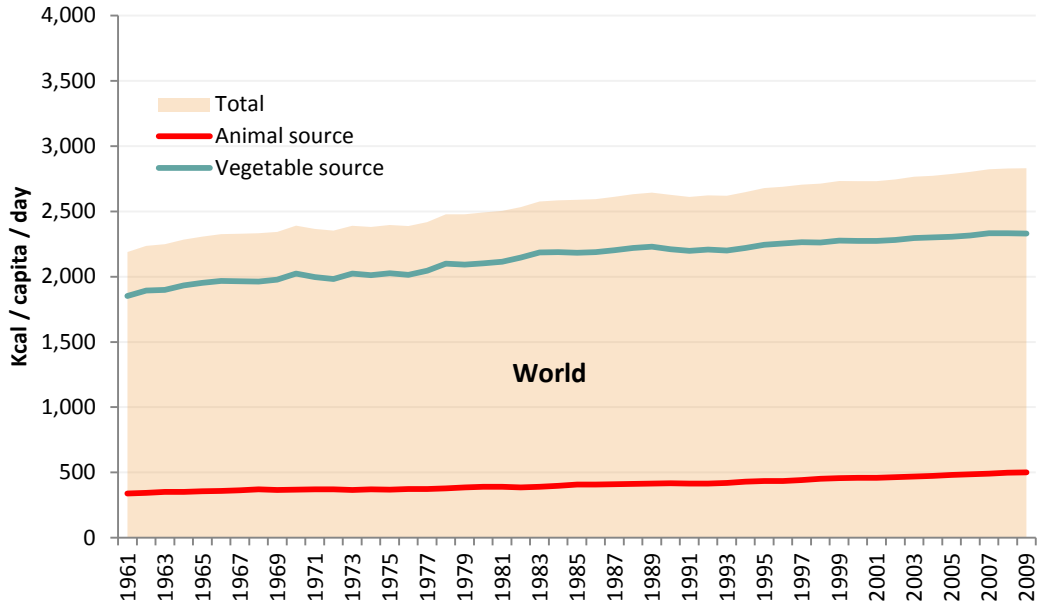
Appendices

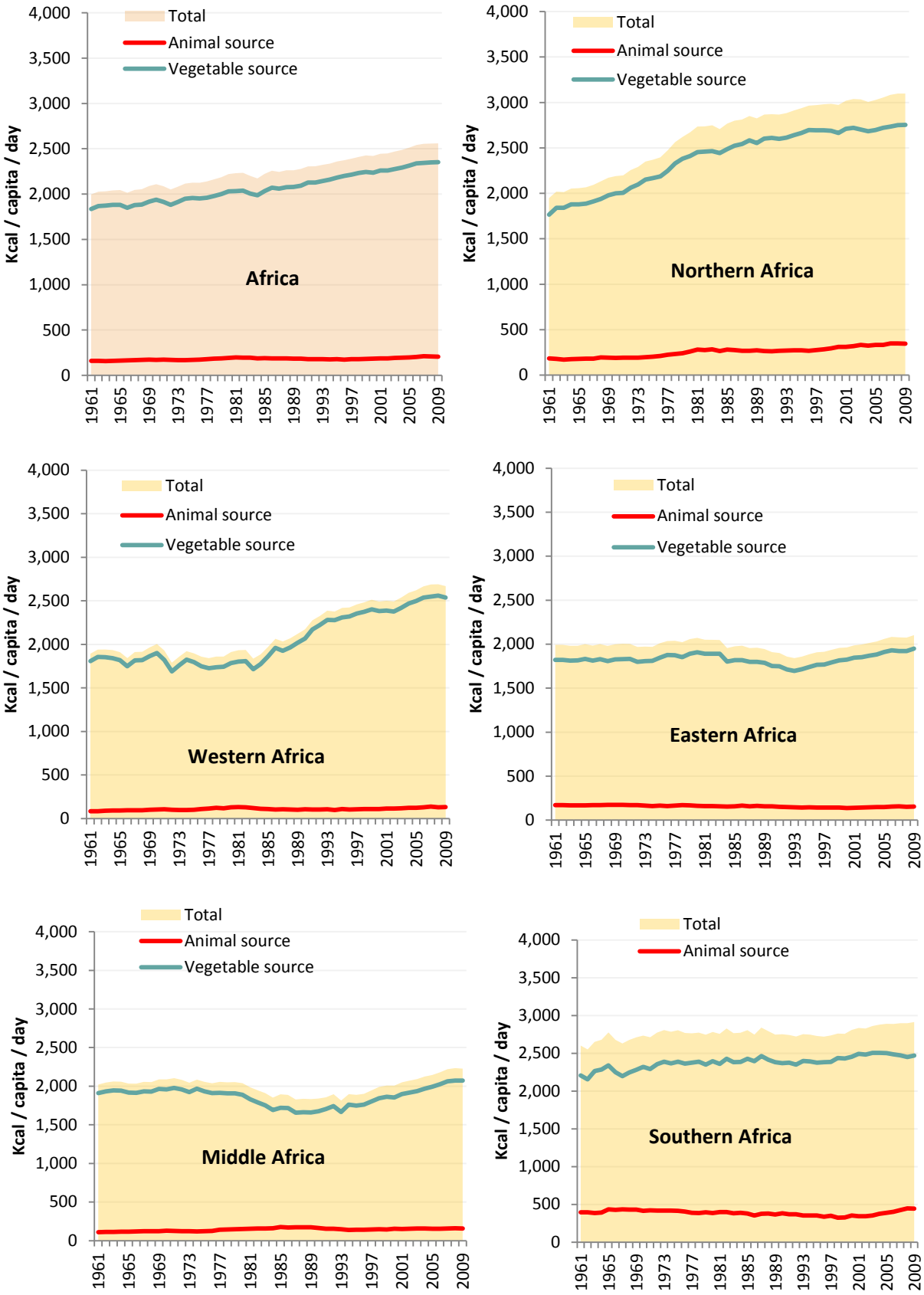
A1: Energy per person per day, 1961 to 2009

Figure A1.1 Trends in proportion of calories from animal and vegetable sources, global average, 1961-2009



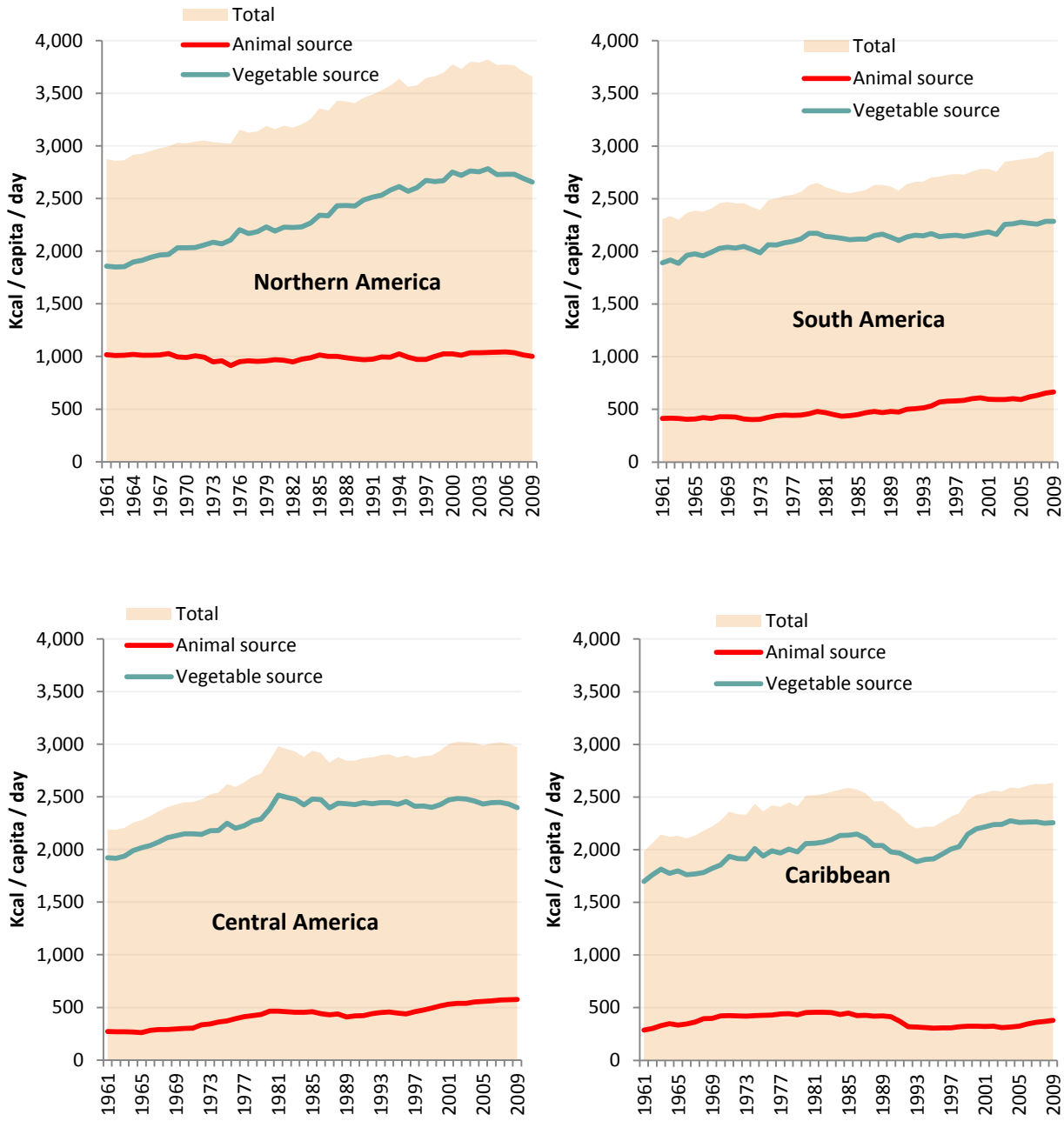
Source: FAOSTAT.

Figure A1.2 Trends in proportion of calories from animal and vegetable sources in Africa, 1961-2009



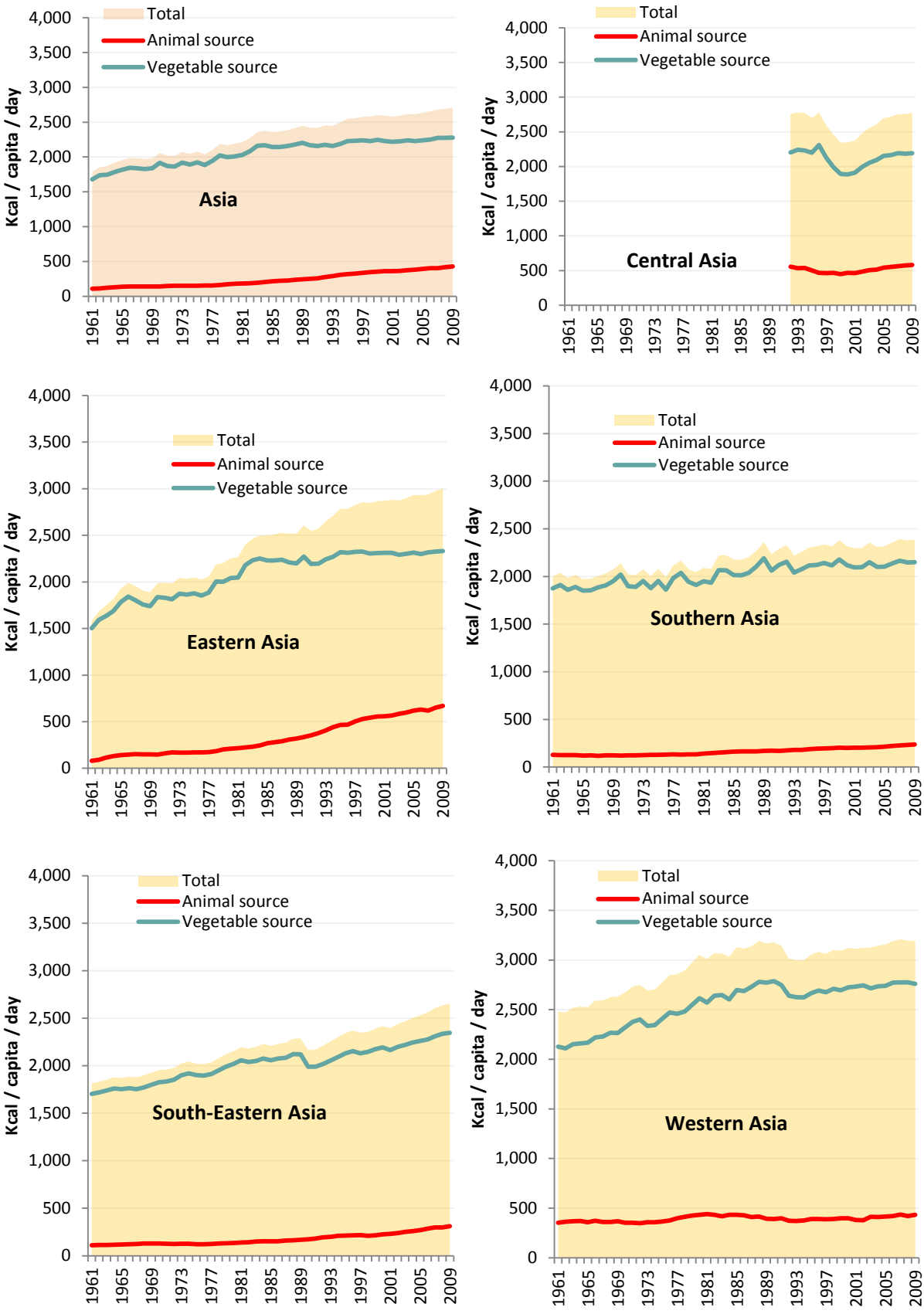
Source: FAOSTAT.

Figure A1.3 Trends in proportion of calories from animal and vegetable sources in the Americas, 1961-2009



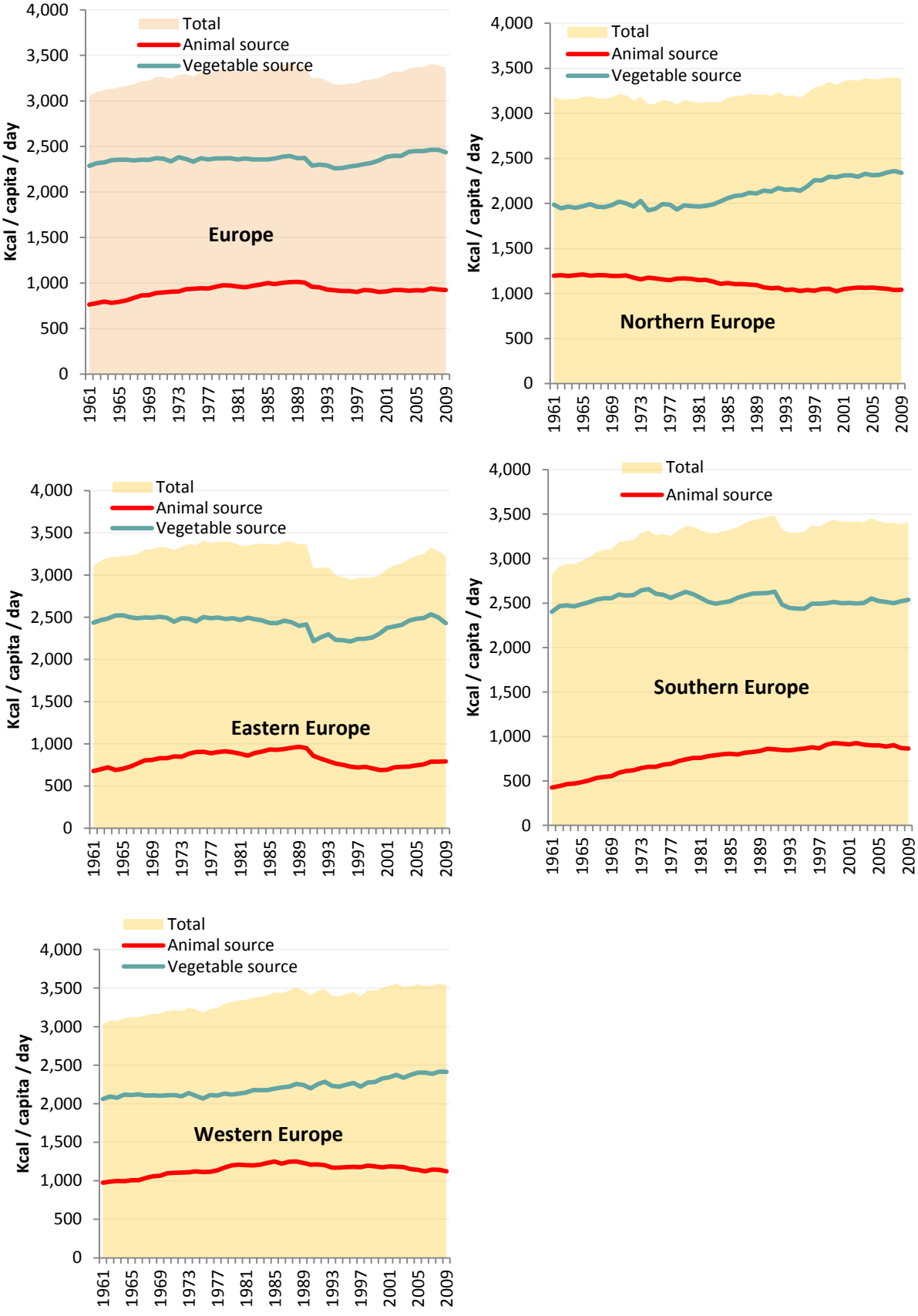
Source: FAOSTAT.

Figure A1.4 Trends in proportion of calories from animal and vegetable sources in Asia, 1961-2009



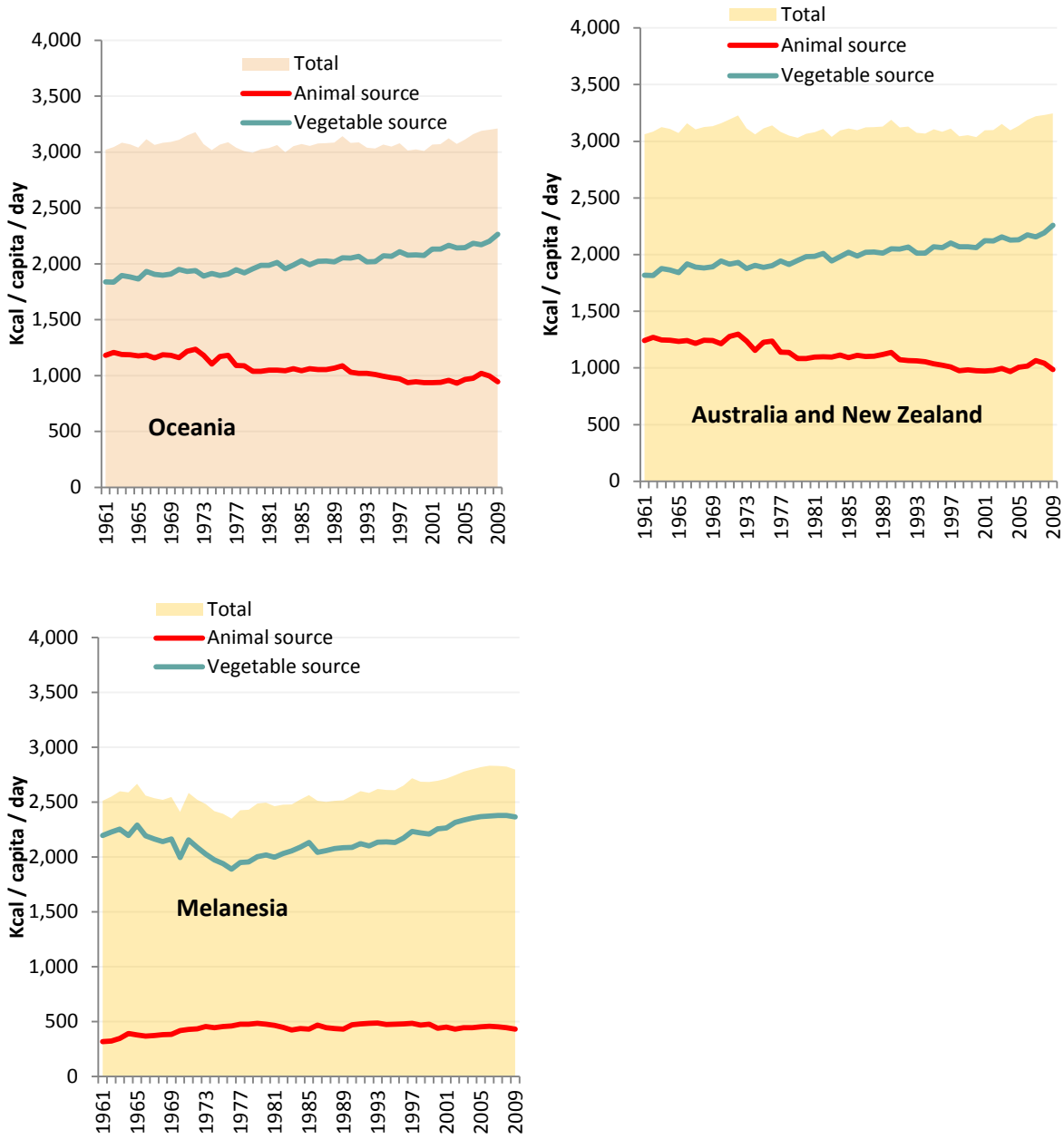
Source: FAOSTAT

Figure A1.5 Trends in proportion of calories from animal and vegetable sources in Europe, 1961-2009



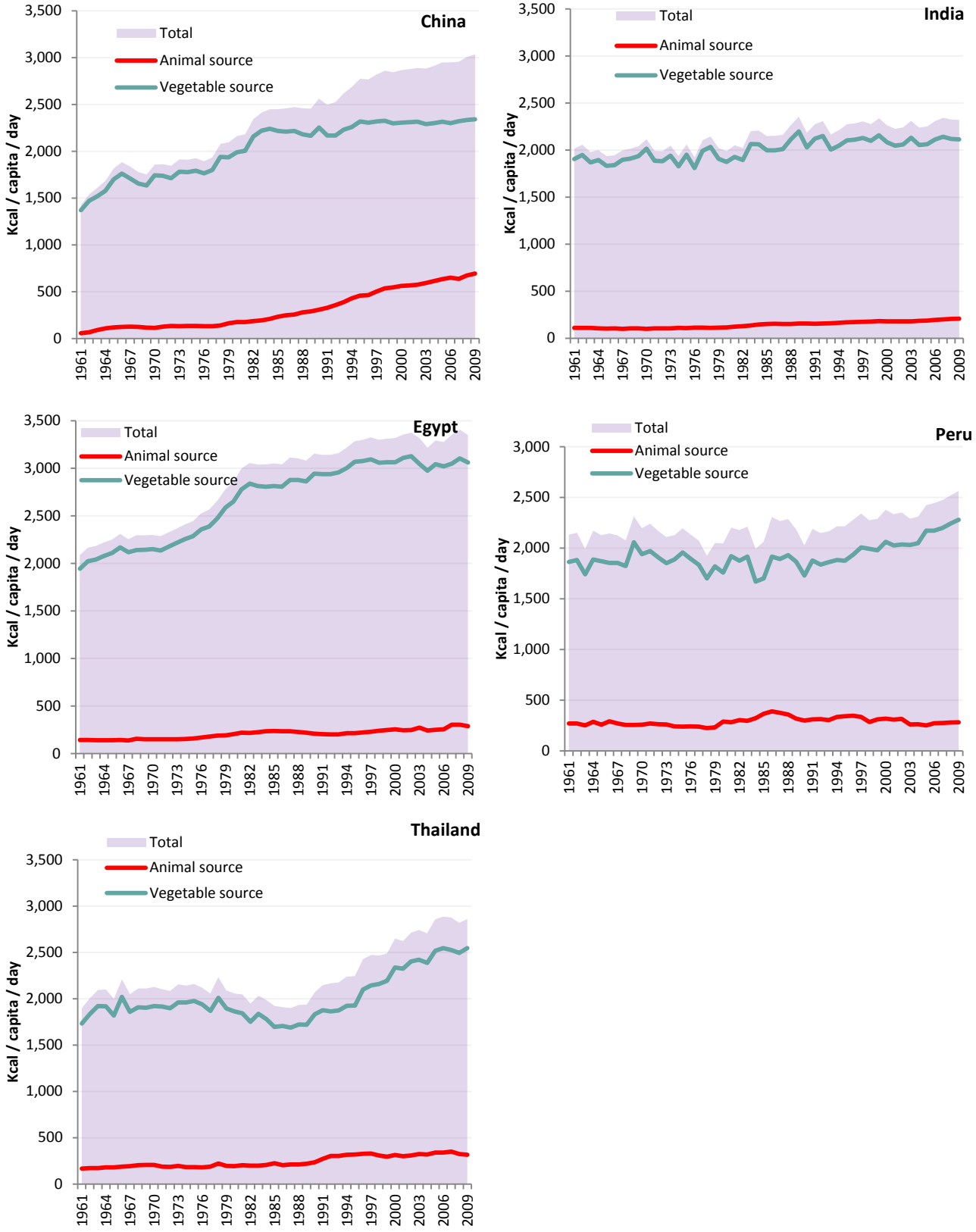
Source: FAOSTAT.

Figure A1.6 Trends in proportion of calories from animal and vegetable sources in Oceania, 1961-2009



Source: FAOSTAT.

Figure A1.7 Trends in proportion of calories from animal and vegetable sources in case study countries, 1961-2009

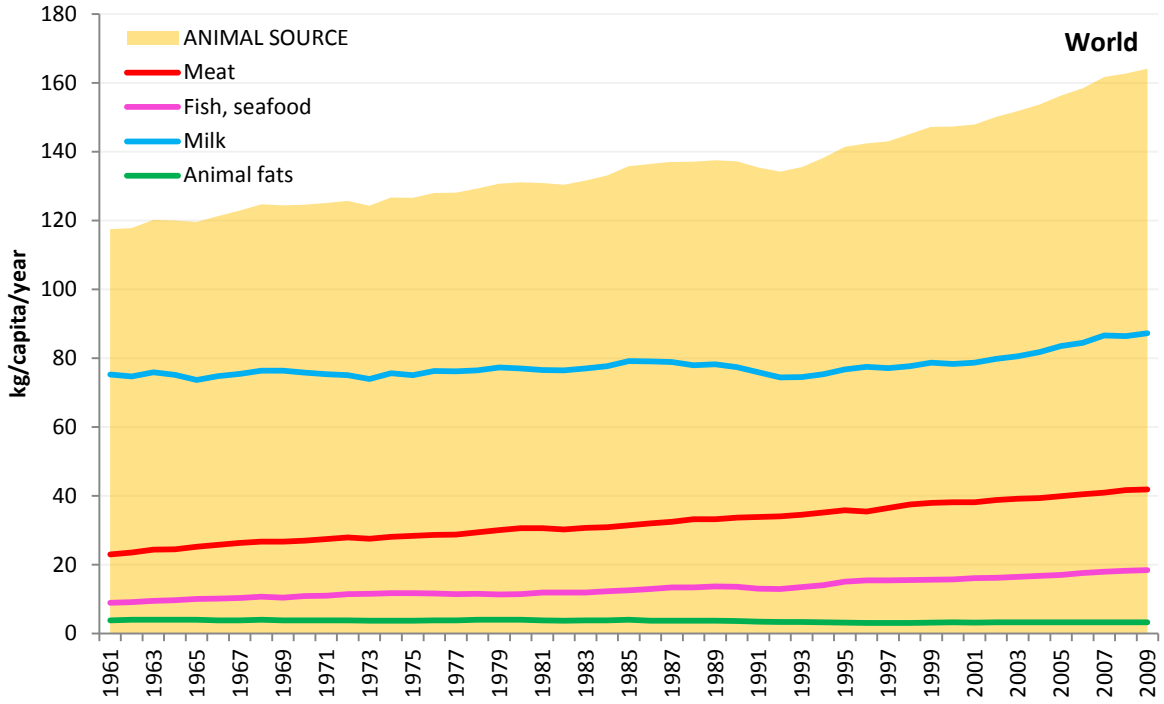


Source: FAOSTAT.

A2: Animal source foods per person per year, 1961 to 2009

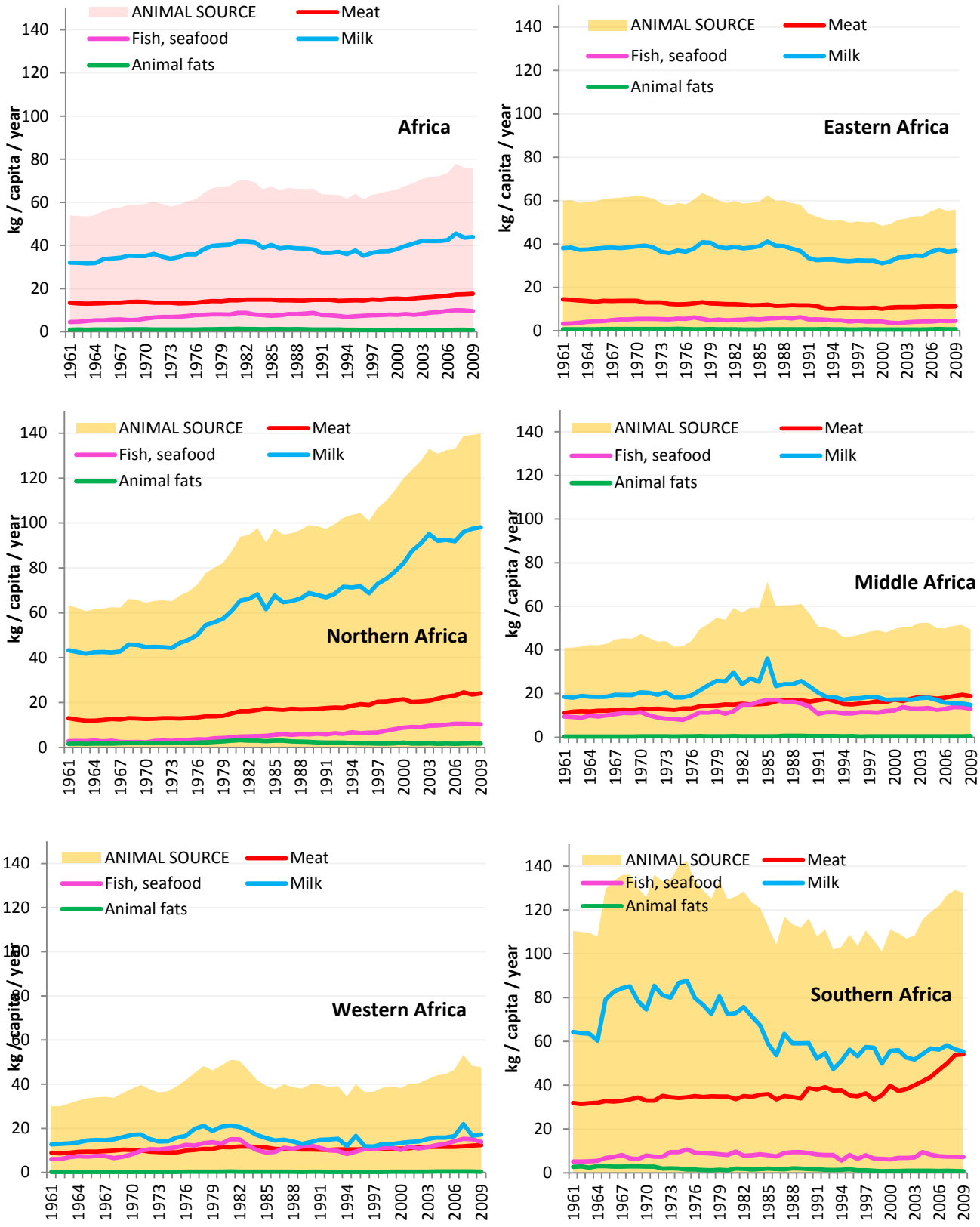
The following figures show total animal source foods in kilograms supplied per capita per year, as well as subtotals for meat, fish and seafood, milk, and animal fats. The totals are larger than the sum of these sub-categories as they include other animal source foods like eggs and offal. Animal fats are revisited together with vegetable fats in Appendix 4.

Figure A2.1 Kilograms of animal source foods per capita, global average, 1961-2009



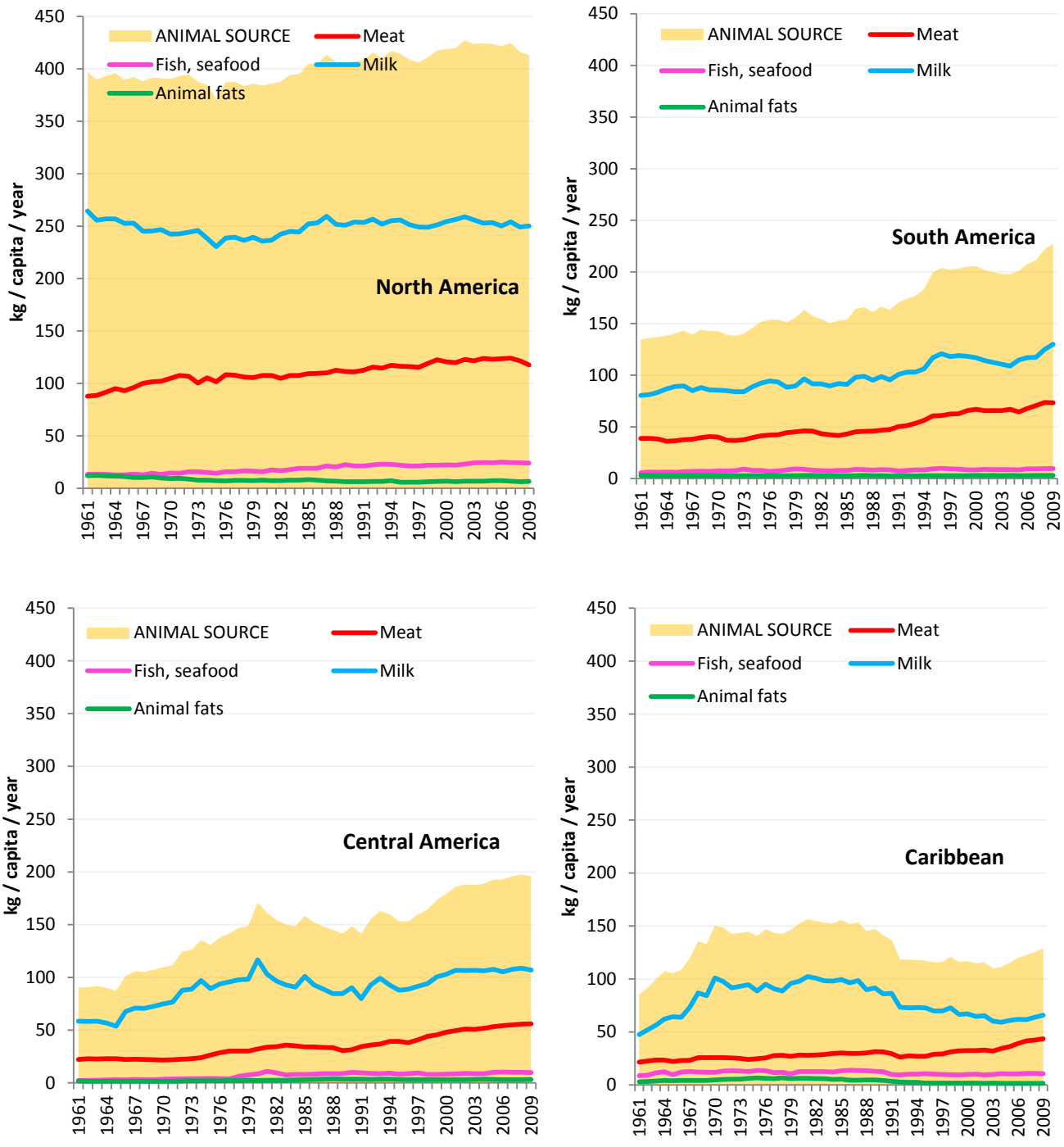
Source: FAOSTAT.

Figure A2.2 Kilograms of animal source foods per capita, in Africa, 1961-2009



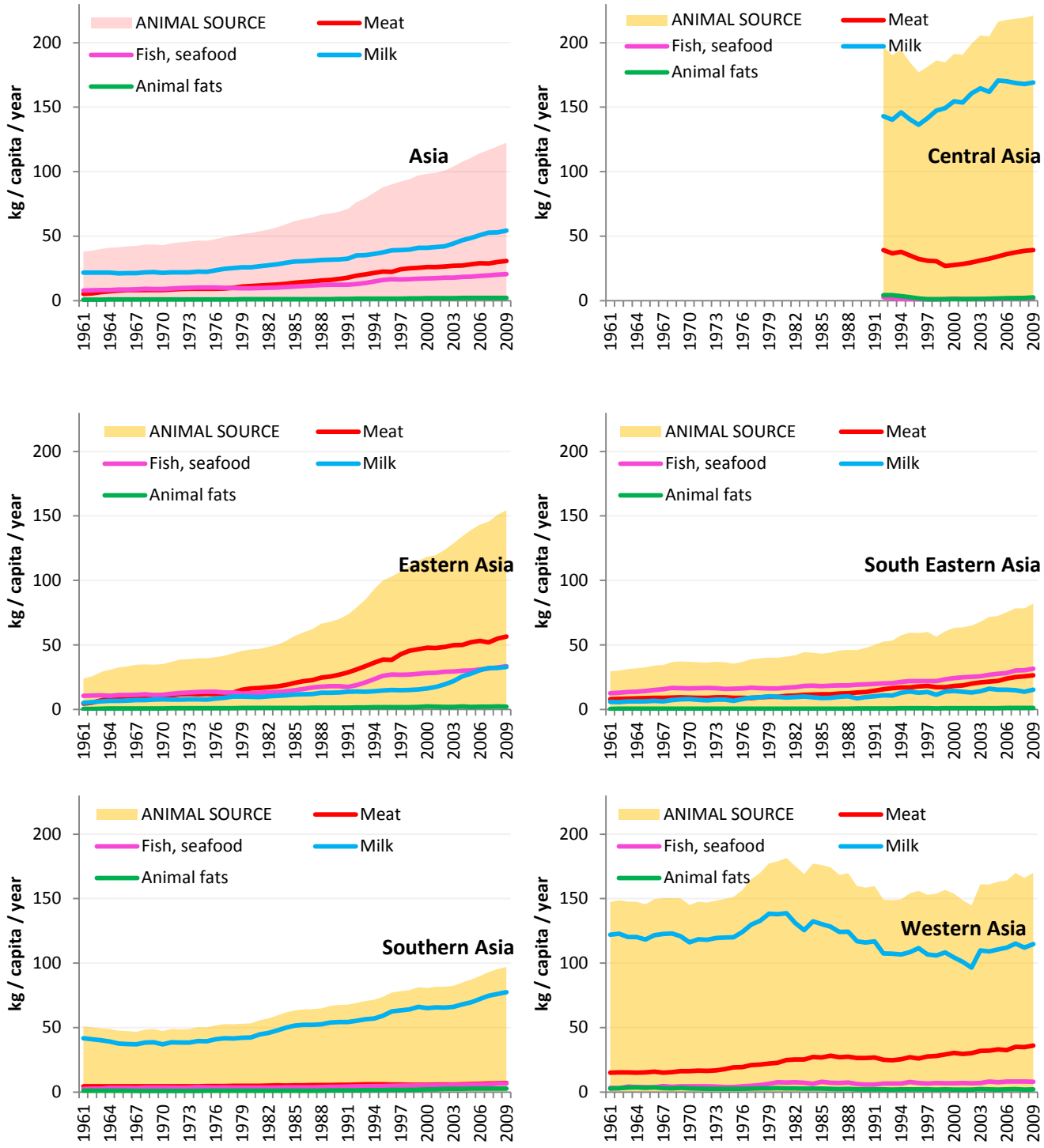
Source: FAOSTAT

Figure A2.3 Kilograms of animal source foods per capita, in the Americas, 1961-2009



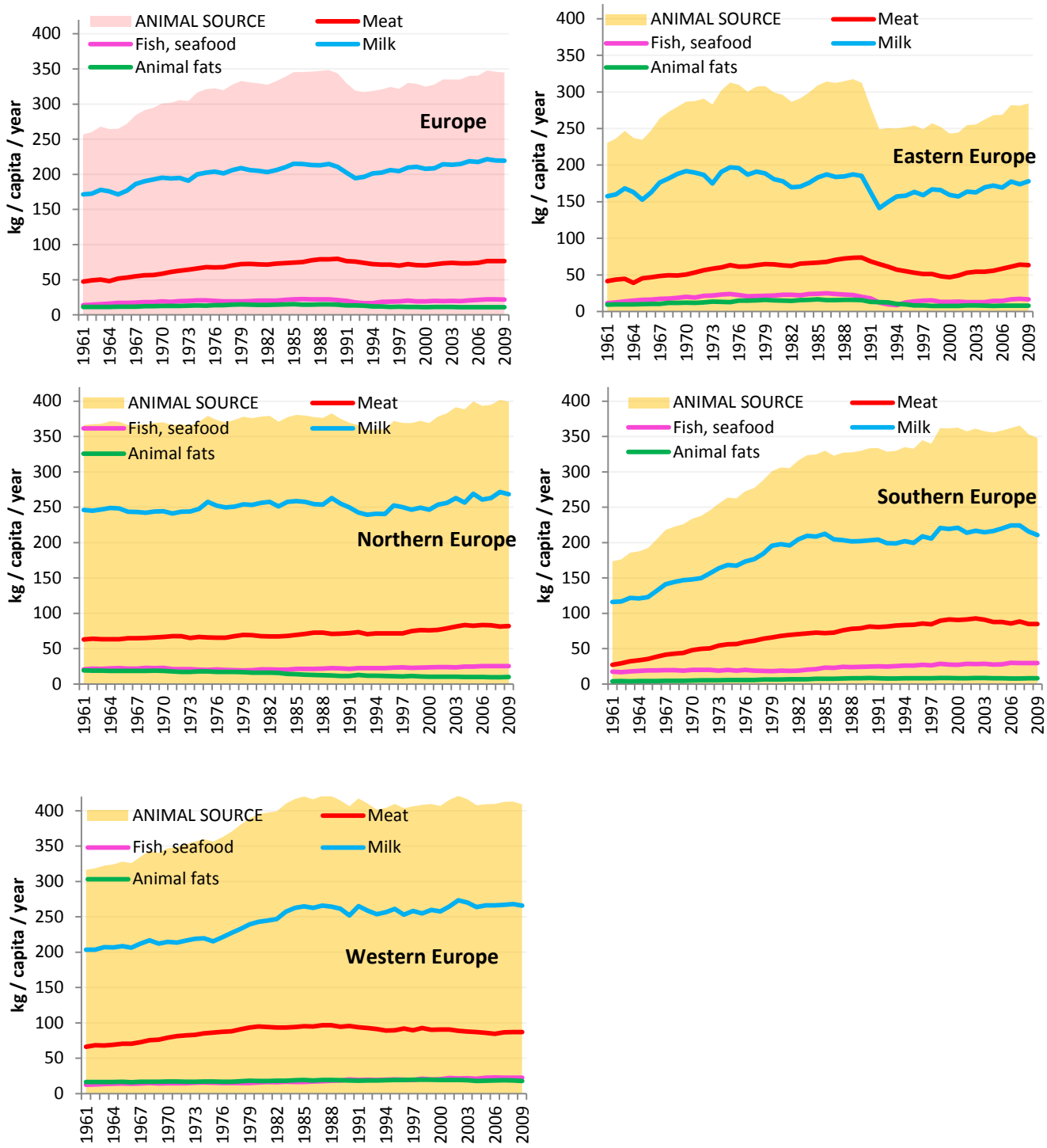
Source: FAOSTAT.

Figure A2.4 Kilograms of animal source foods per capita, in Asia, 1961-2009



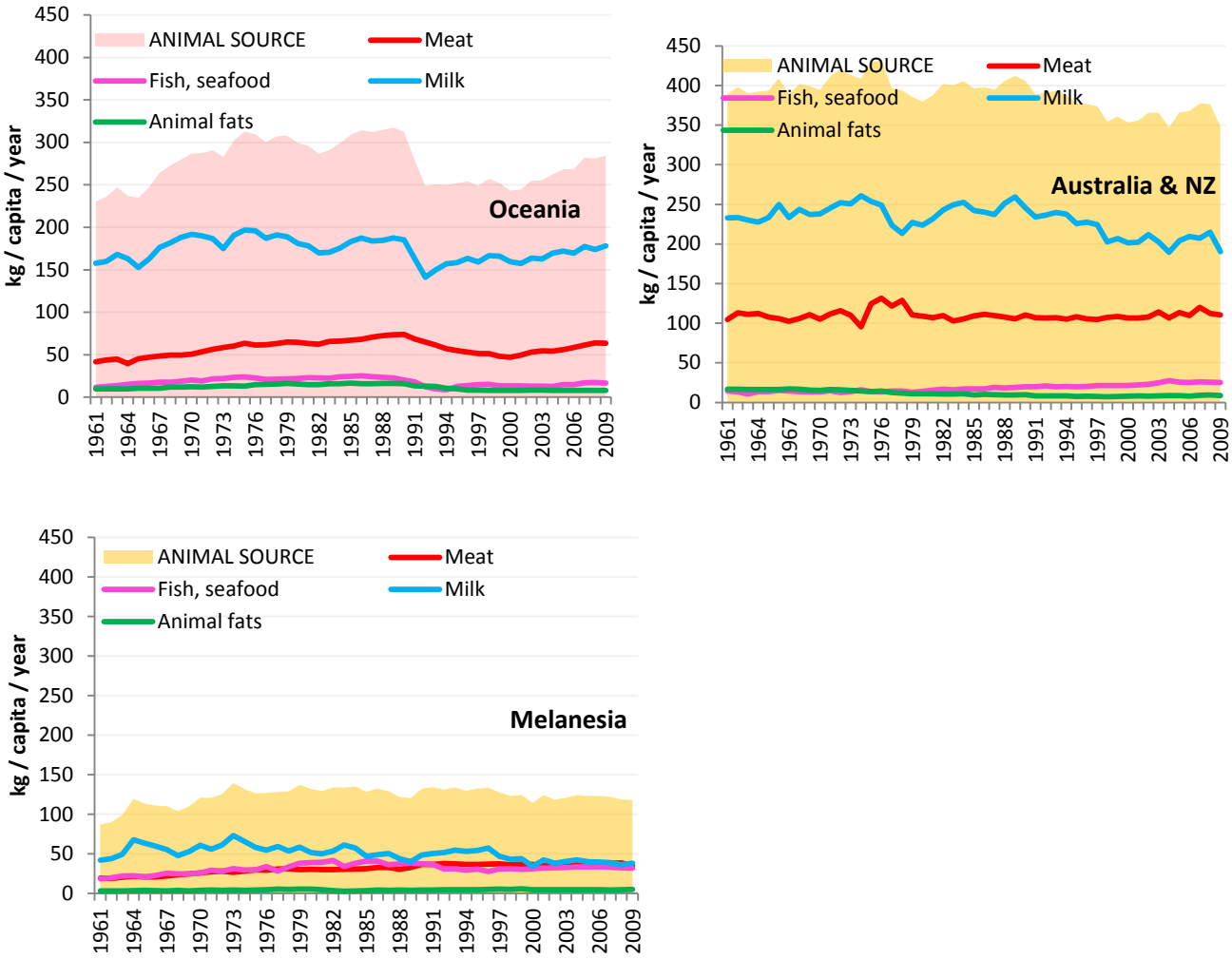
Source: FAOSTAT.

Figure A2.5 Kilograms of animal source foods per capita, in Europe, 1961-2009



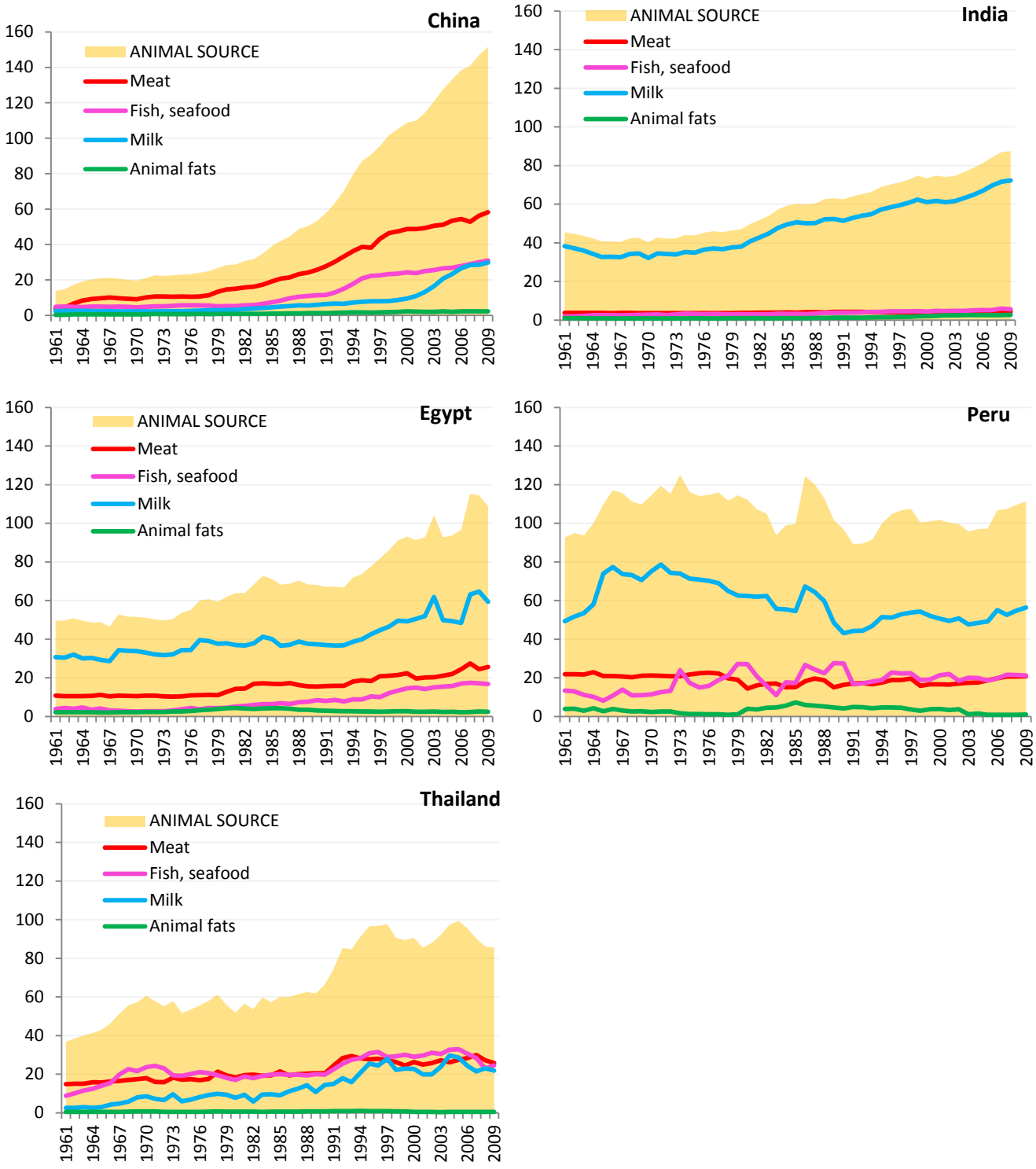
Source: FAOSTAT.

Figure A2.6 Kilograms of animal source foods per capita, in Oceania, 1961-2009



Source: FAOSTAT.

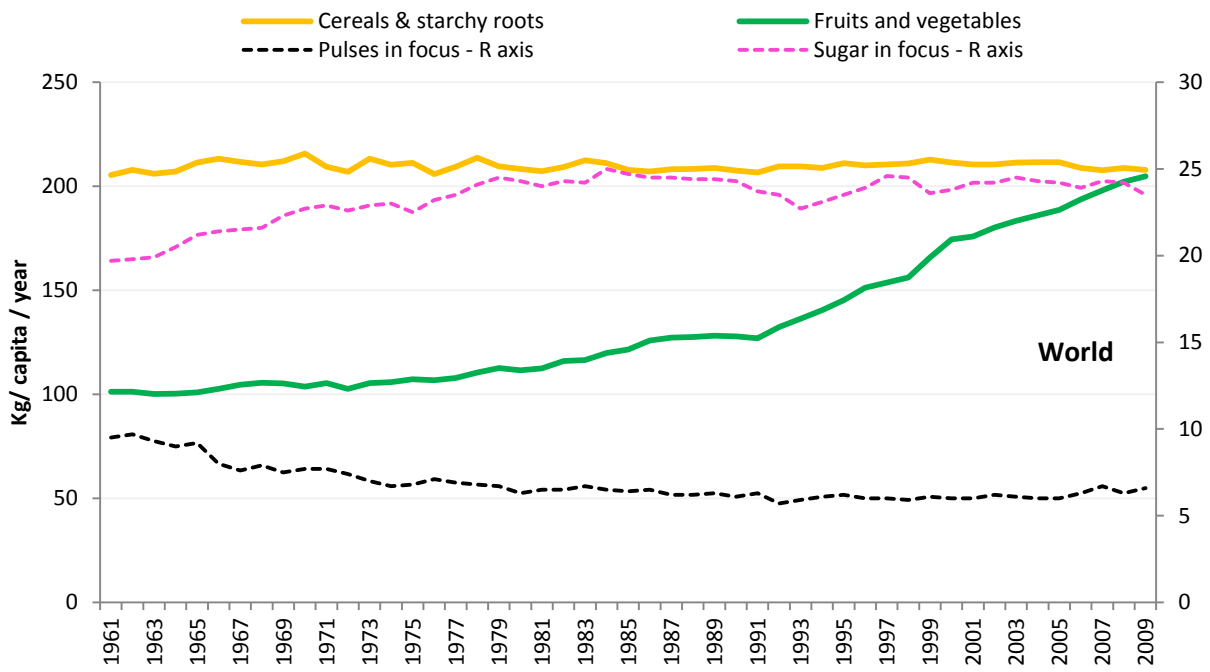
Figure A2.7 Kilograms of animal source foods per capita, in five case study countries, 1961-2009



Source: FAOSTAT.

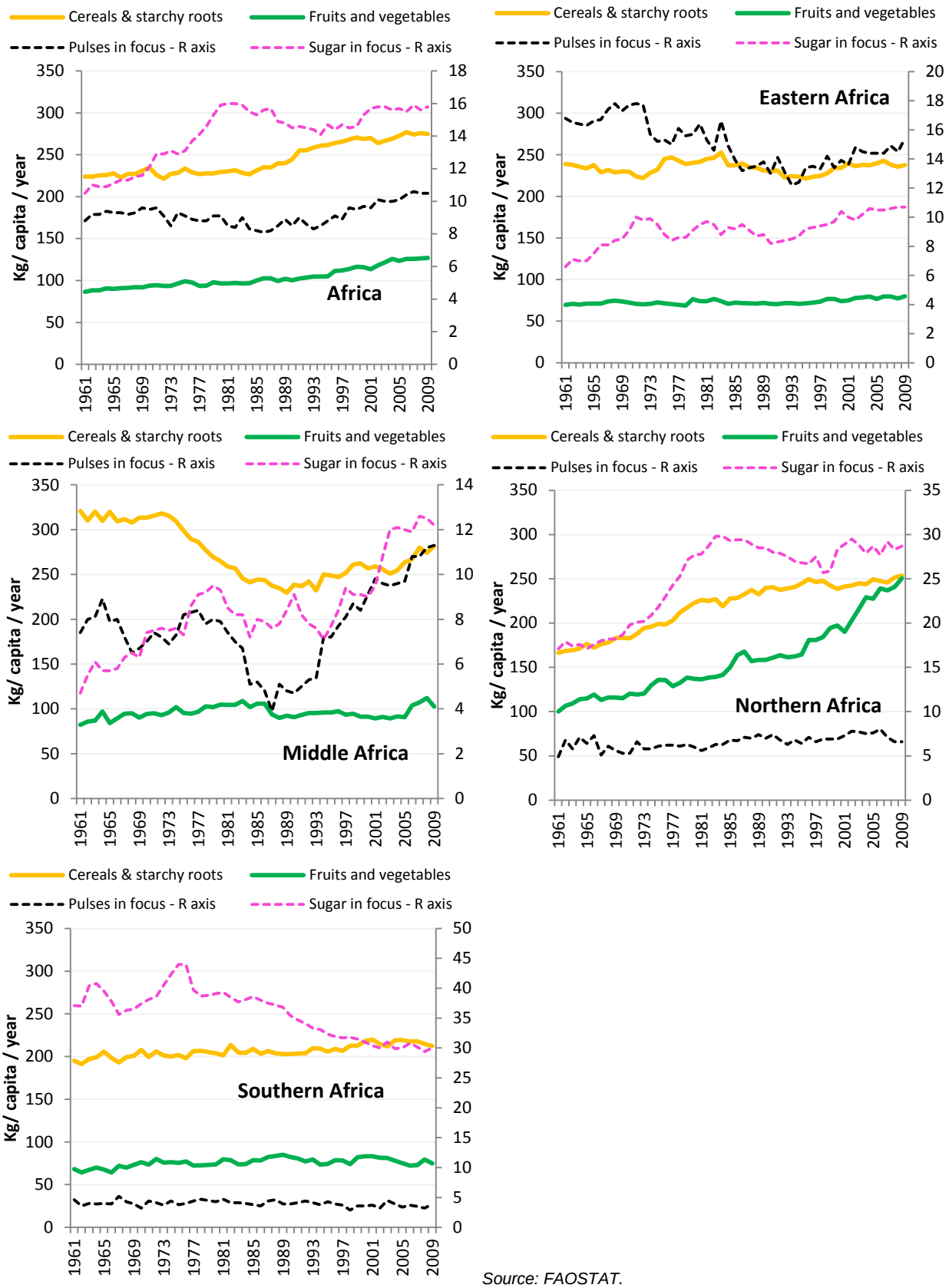
A3: Vegetables, fruit, pulses, sugar per person per year, 1961 to 2009

Figure A3.1 Kilograms of starchy staples, fruits and vegetables, pulses, and sugar per capita, global average, 1961-2009



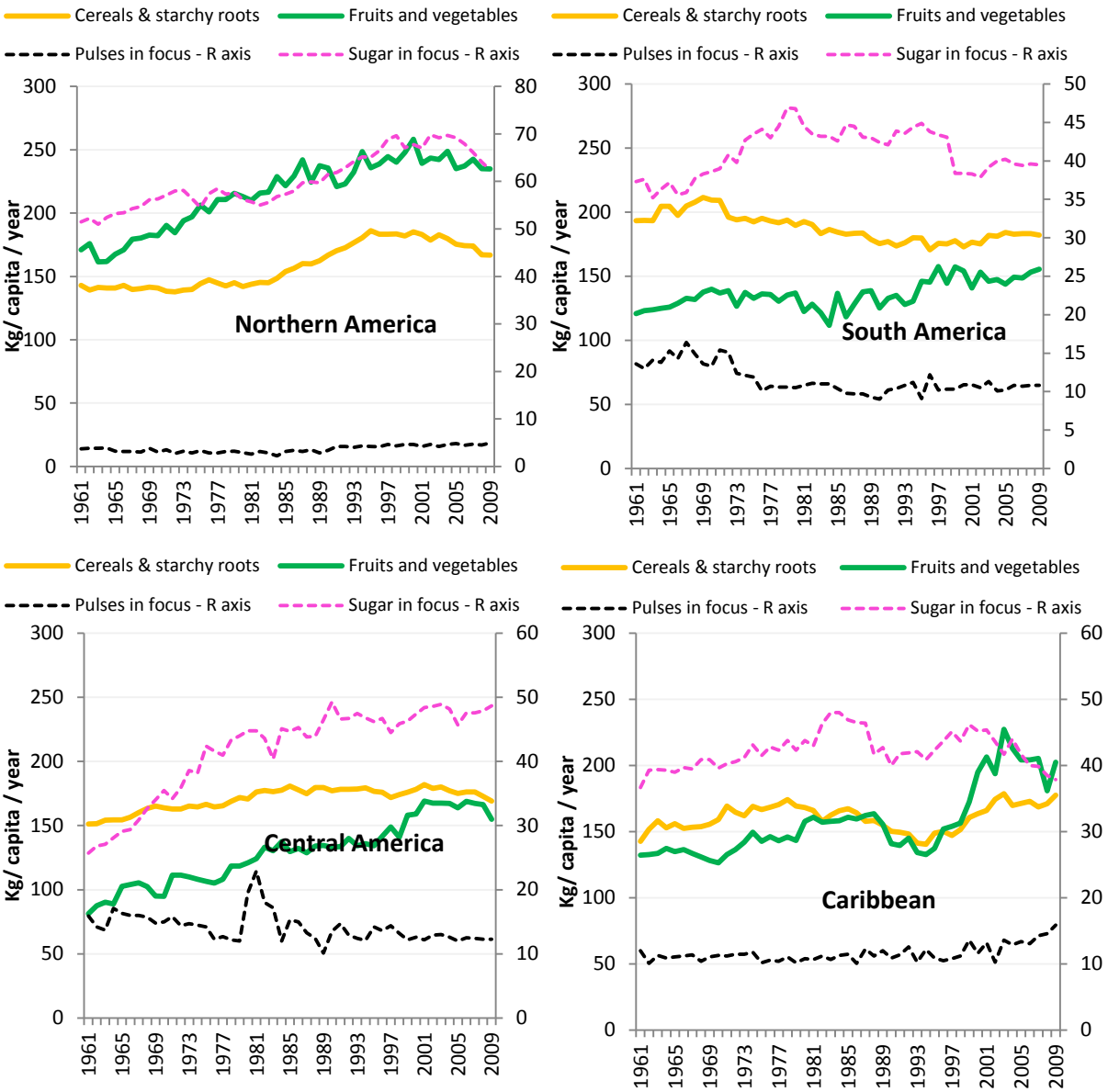
Source: FAOSTAT.

Figure A3.2 Kilograms of starchy staples, fruits and vegetables, pulses, and sugar per capita, Africa, 1961-2009



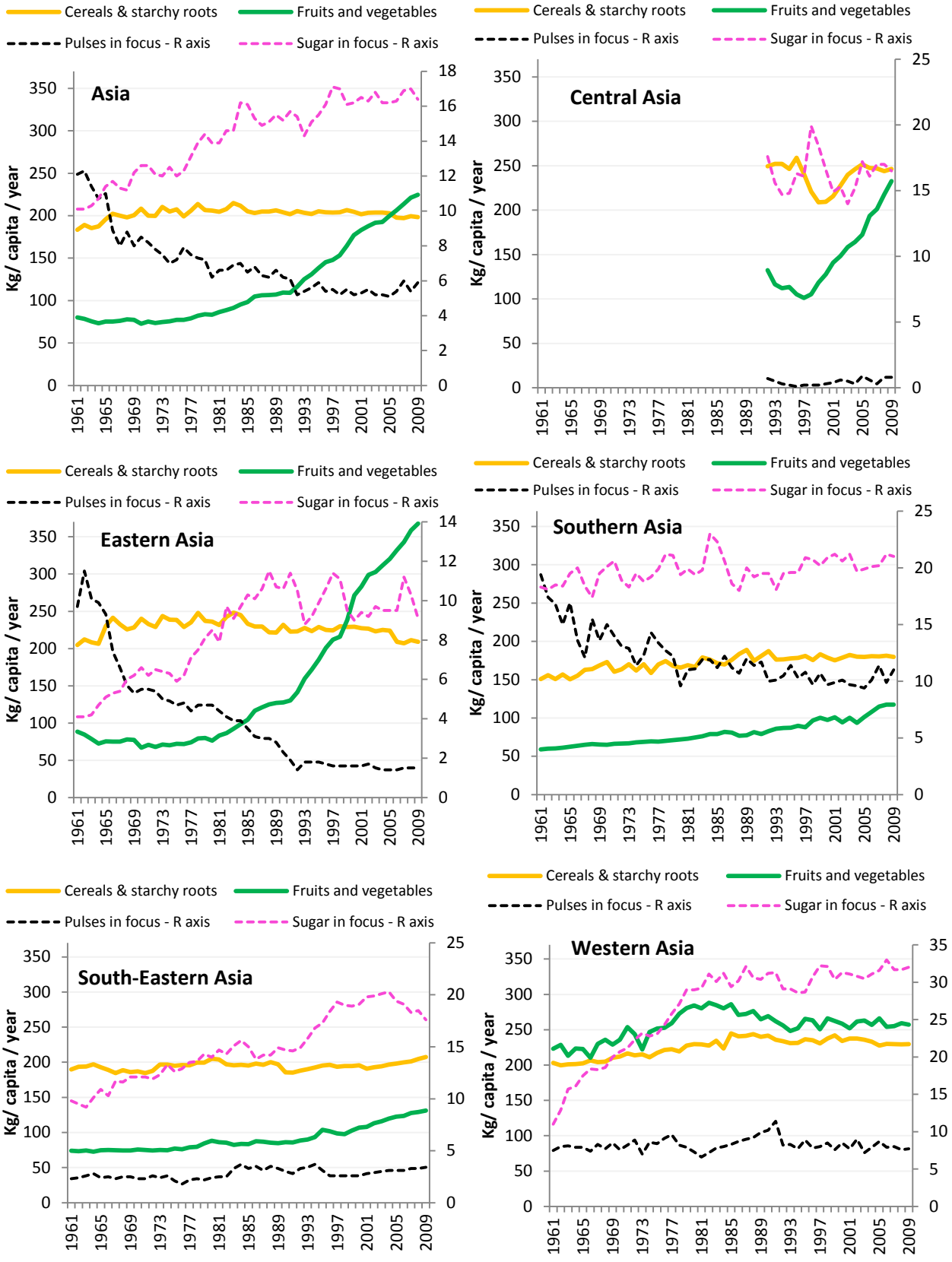
Source: FAOSTAT.

Figure A3.3 Kilograms of starchy staples, fruits and vegetables, pulses, and sugar per capita, the Americas, 1961-2009



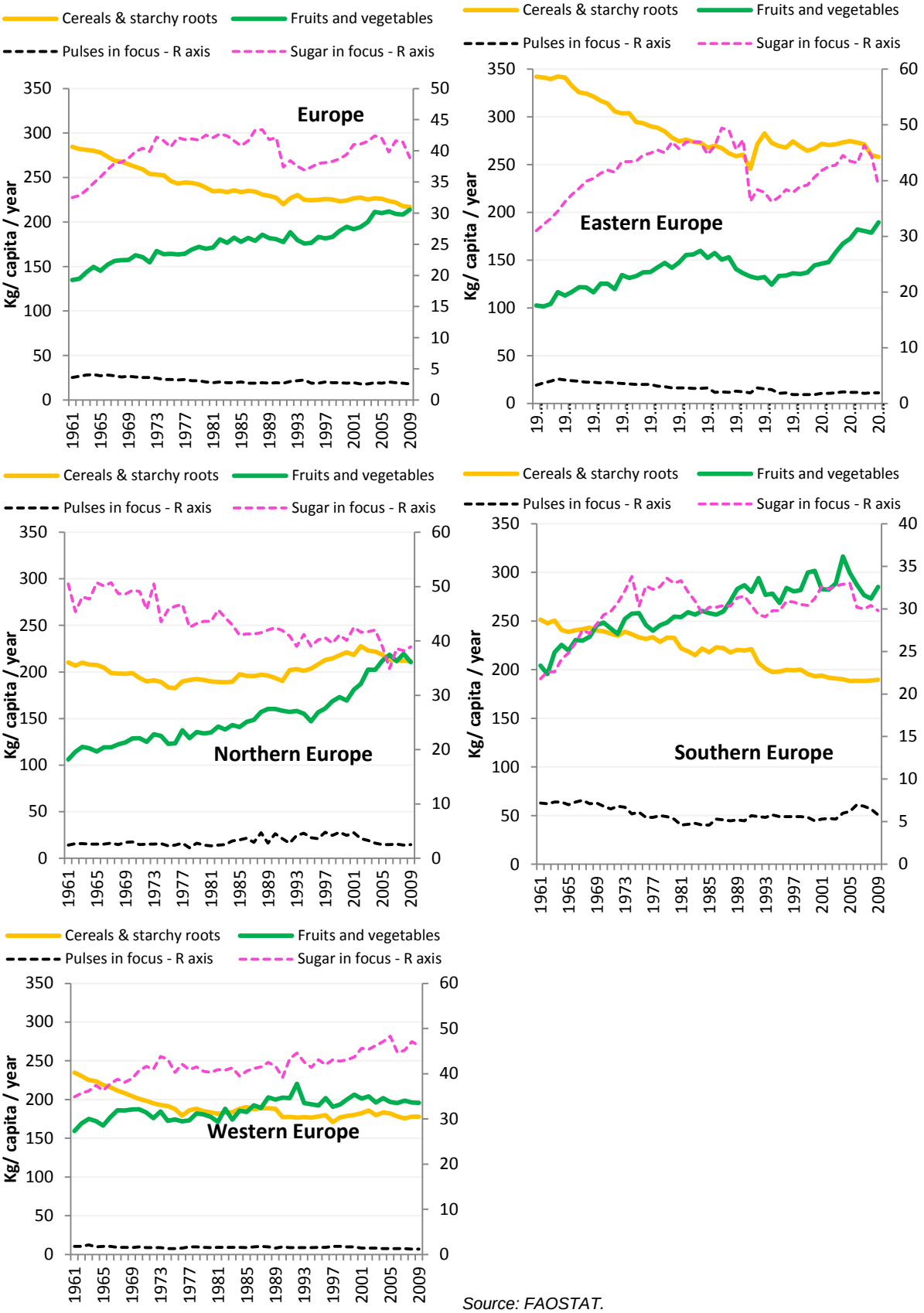
Source: FAOSTAT.

Figure A3.4 Kilograms of starchy staples, fruits and vegetables, pulses, and sugar per capita, Asia, 1961-2009



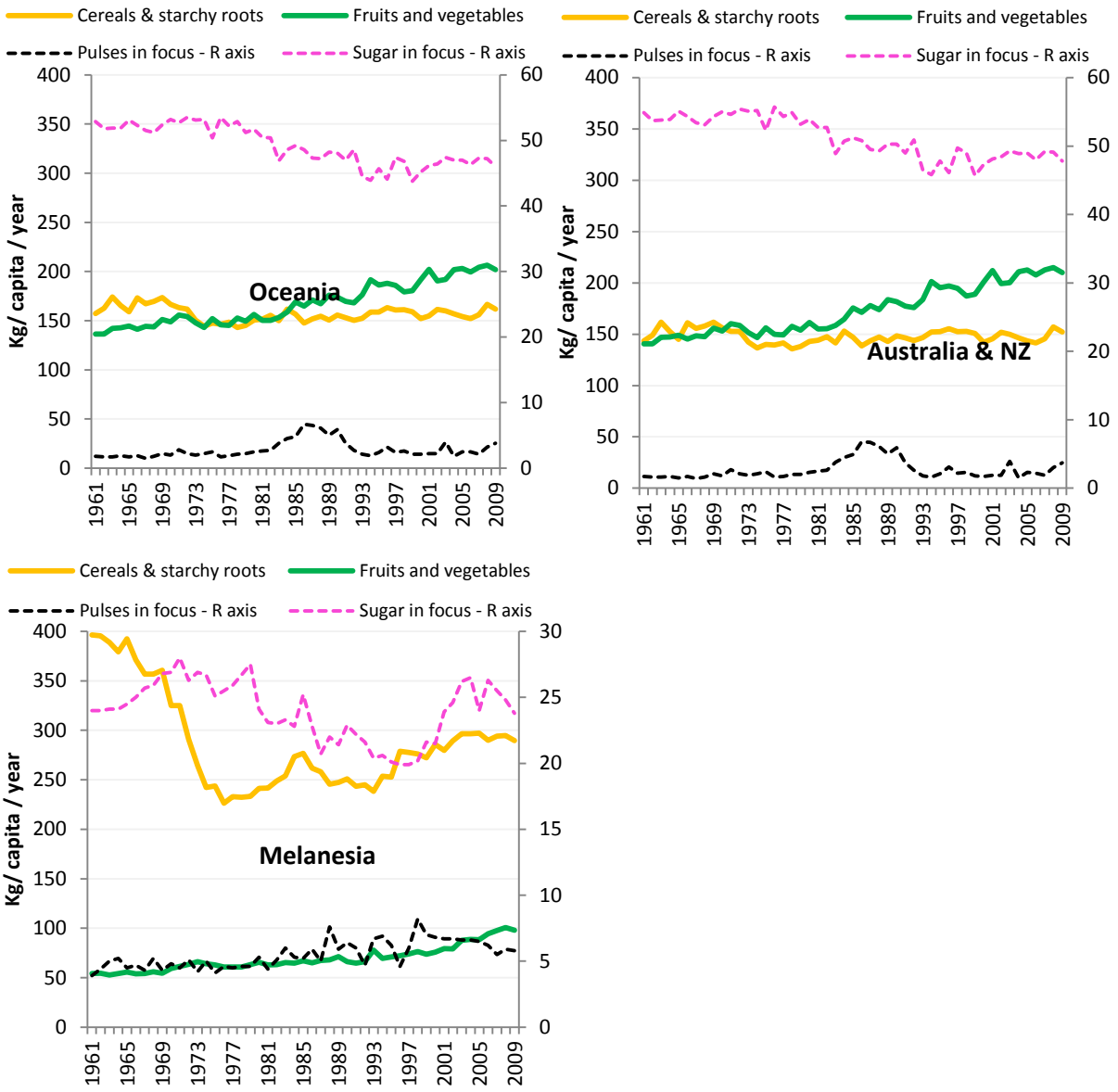
Source: FAOSTAT.

Figure A3.5 Kilograms of starchy staples, fruits and vegetables, pulses, and sugar per capita, Europe, 1961-2009



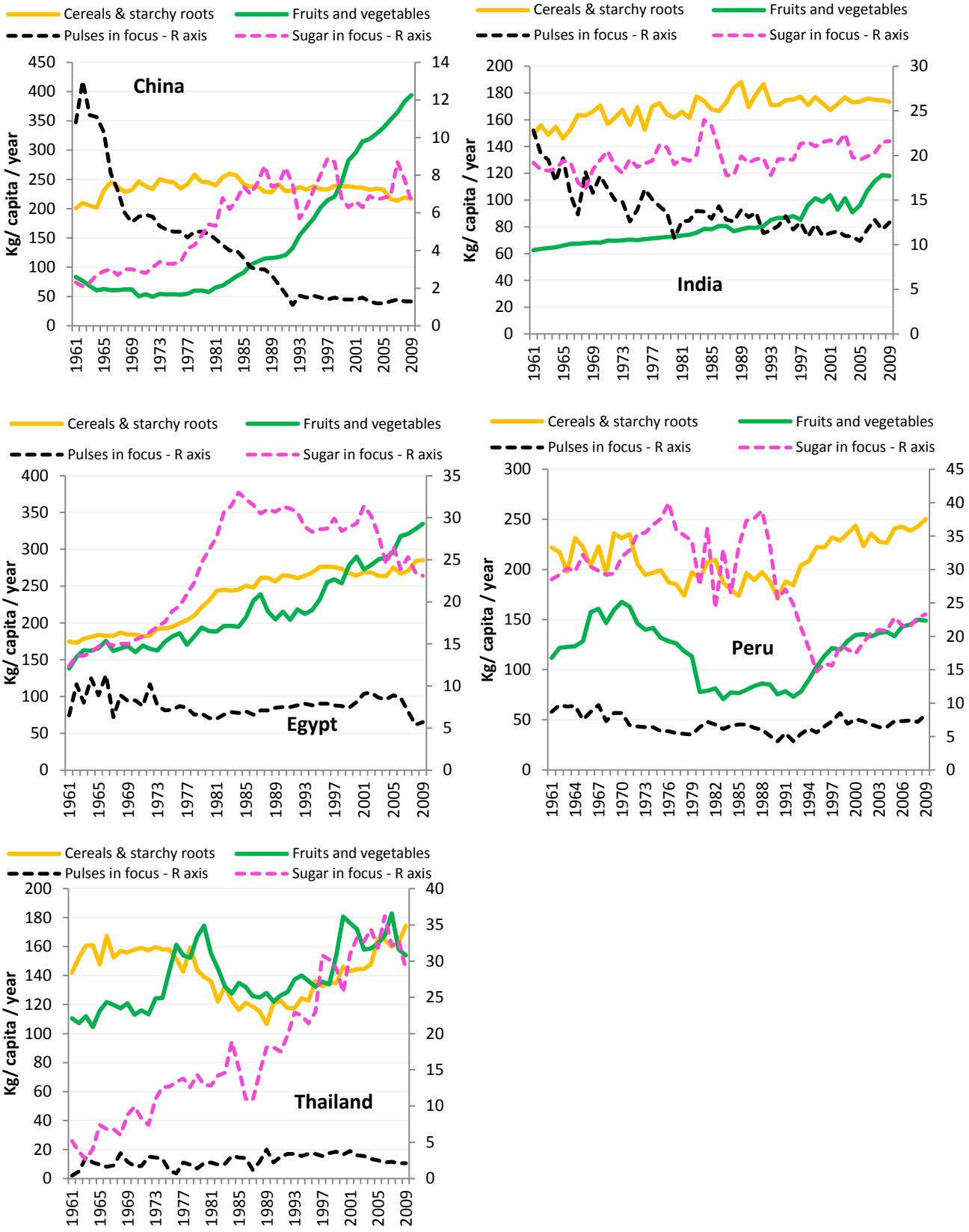
Source: FAOSTAT.

Figure A3.6 Kilograms of starchy staples, fruits and vegetables, pulses, and sugar per capita, Oceania, 1961-2009



Source: FAOSTAT.

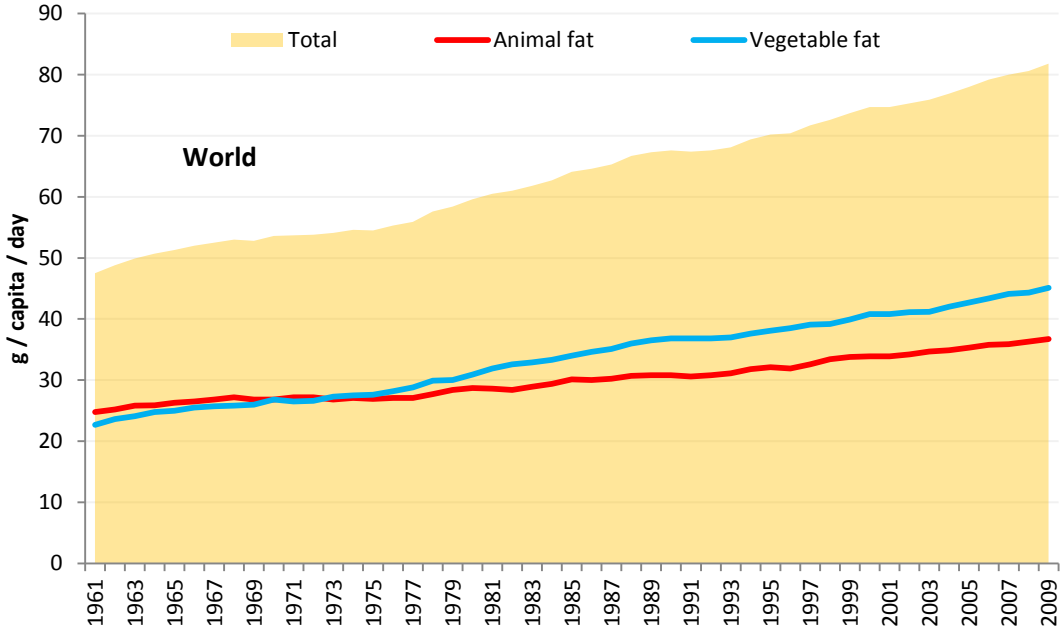
Figure A3.7 Kilograms of starchy staples, fruits and vegetables, pulses, and sugar per capita in case study countries, 1961-2009



Source: FAOSTAT.

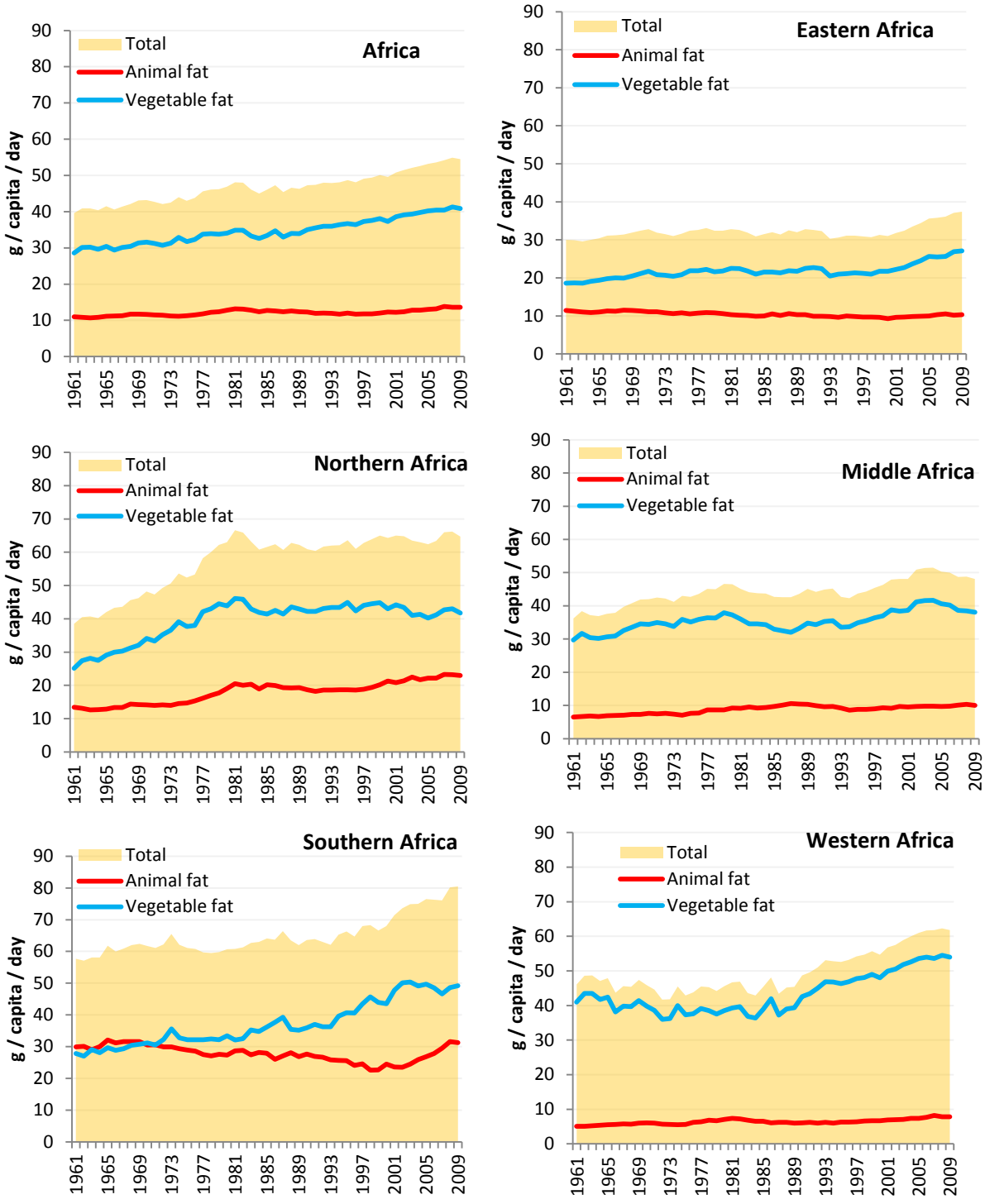
A4: Fats per person per year, 1961 to 2009

Figure A4.1 Grams of animal and vegetable fat per capita, global average, 1961-2009



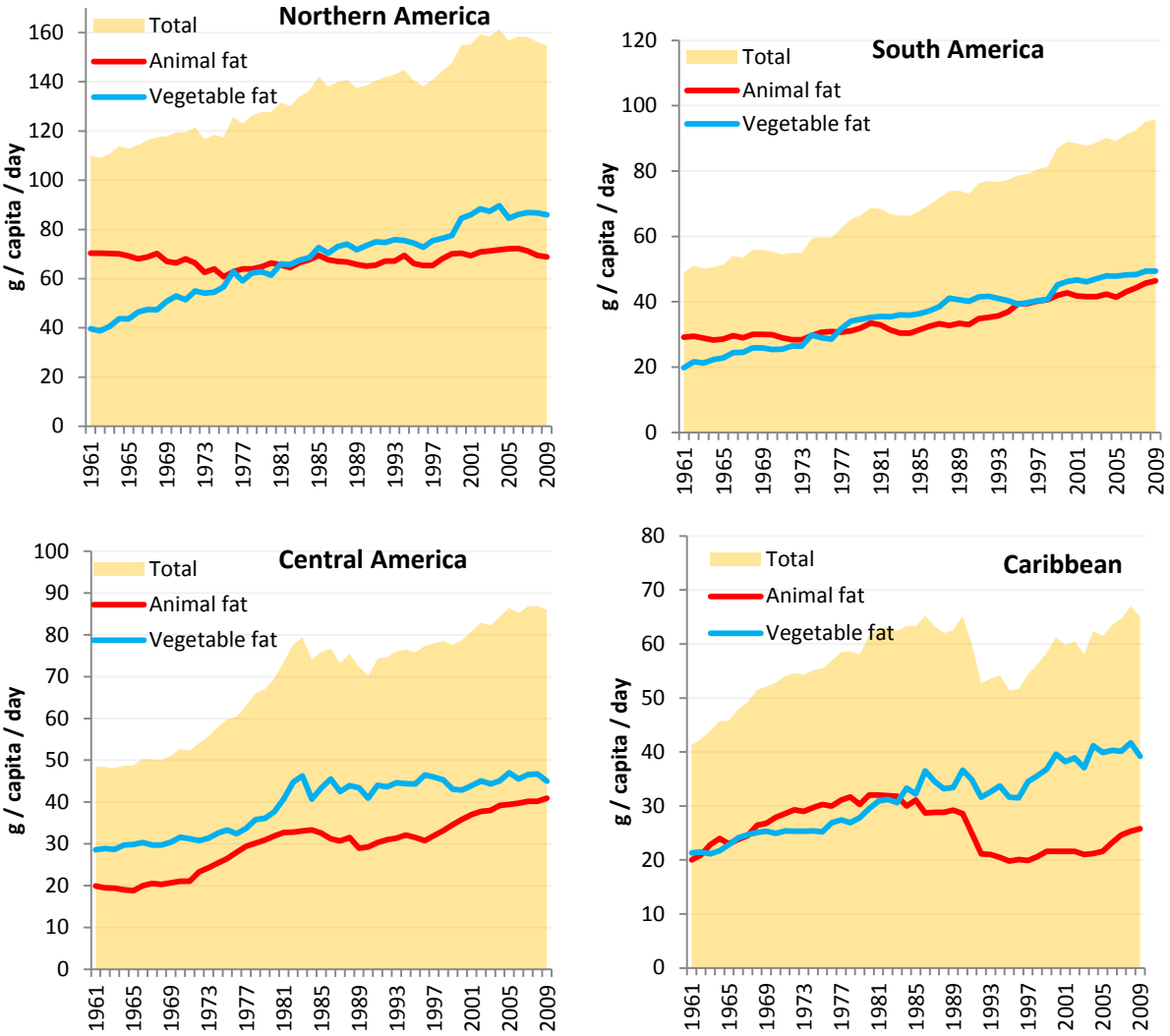
Source: FAOSTAT.

Figure A4.2 Grams of animal and vegetable fat per capita, Africa, 1961-2009



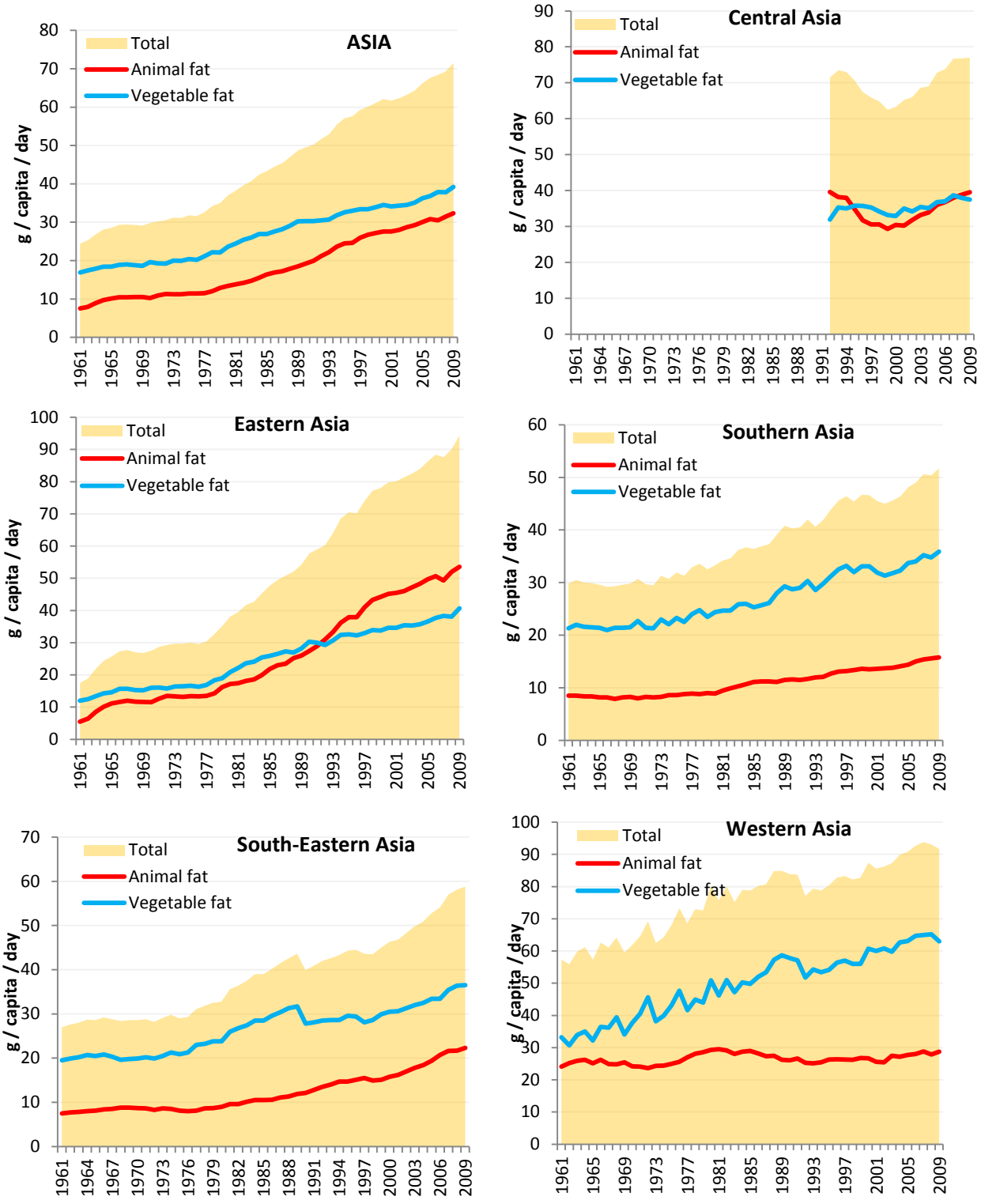
Source: FAOSTAT.

Figure A4.3 Grams of animal and vegetable fat per capita, the Americas, 1961-2009



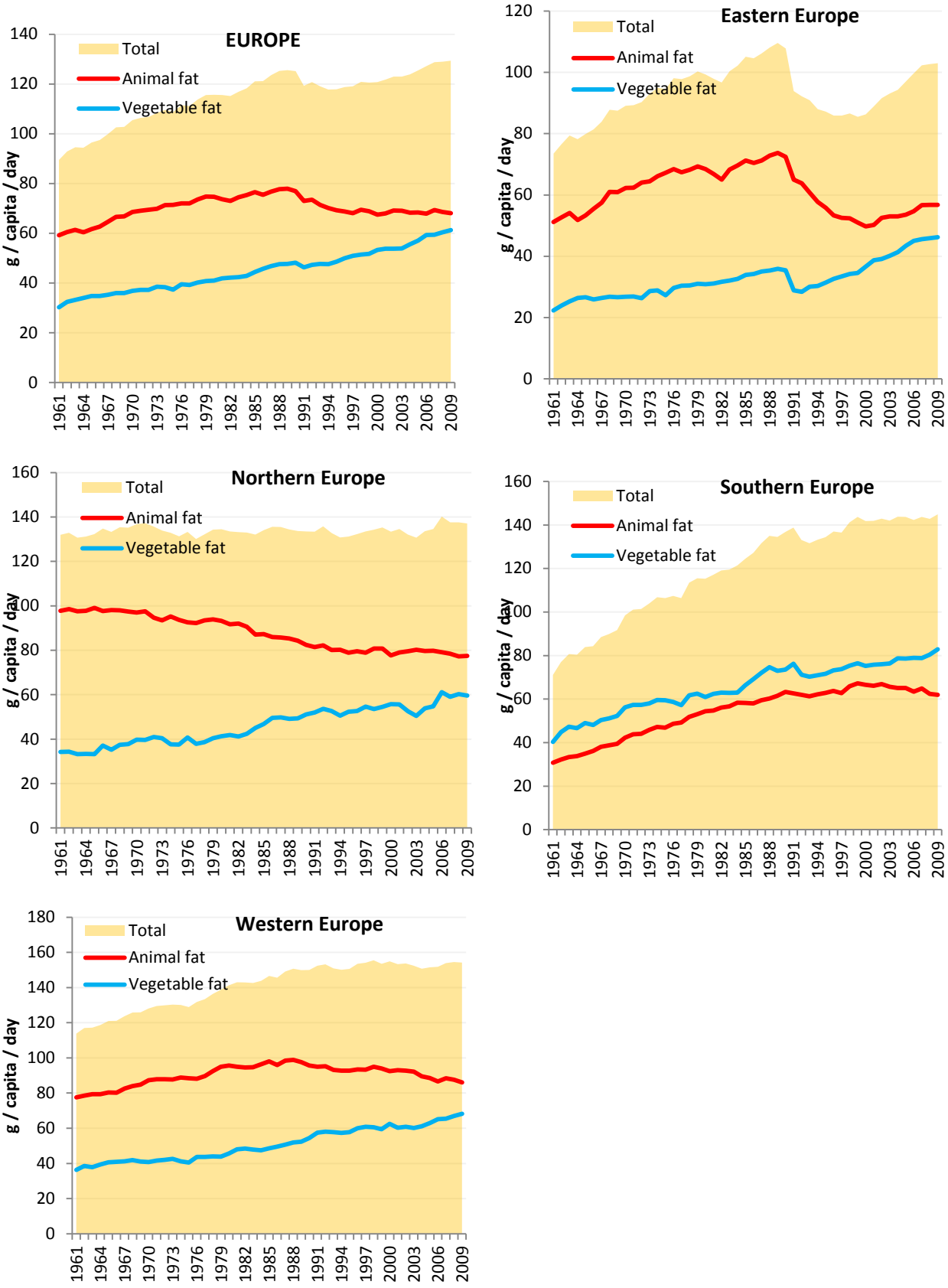
Source: FAOSTAT.

Figure A4.4 Grams of animal and vegetable fat per capita, Asia, 1961-2009



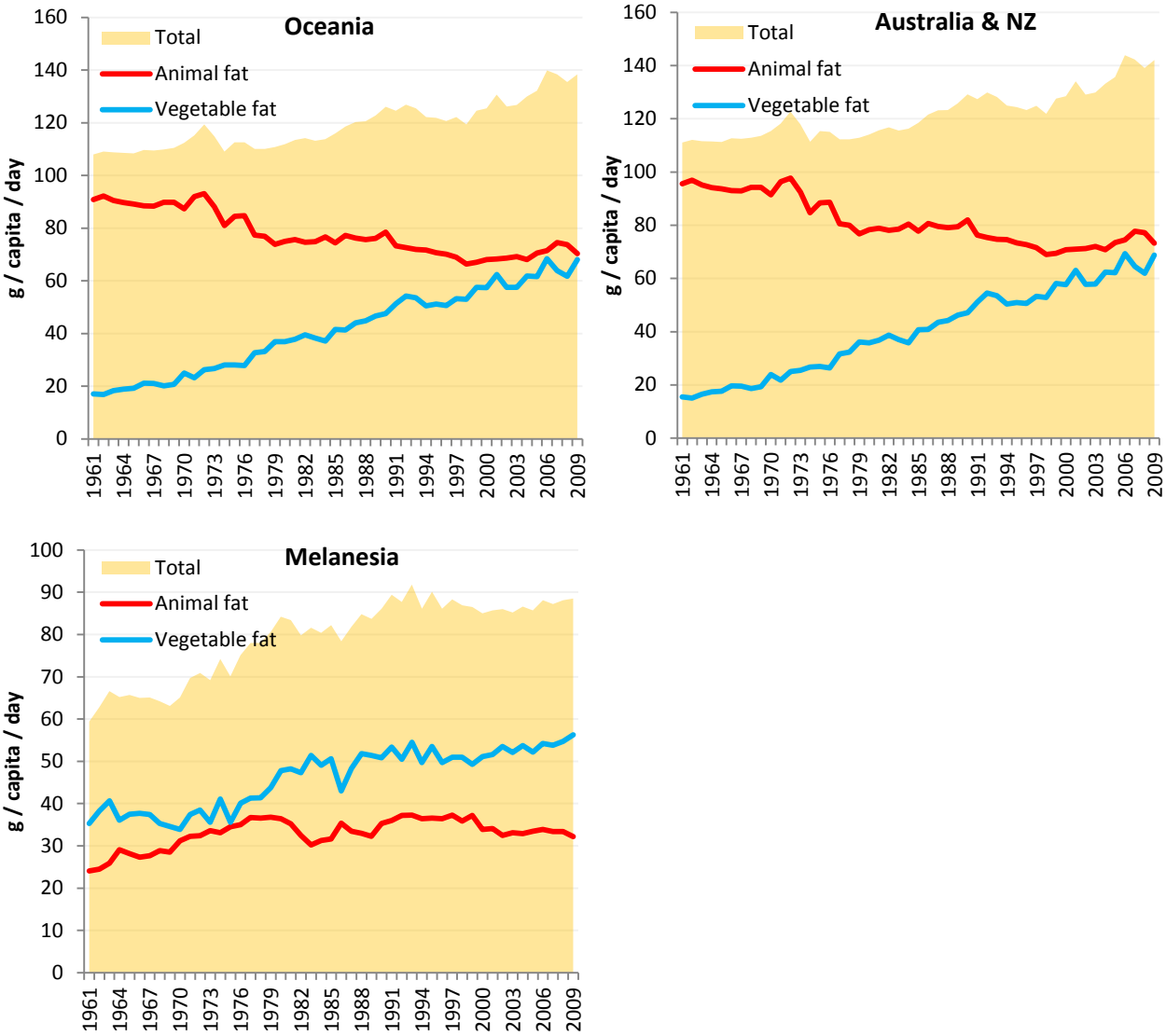
Source: FAOSTAT.

Figure A4.5 Grams of animal and vegetable fat per capita, Europe, 1961-2009



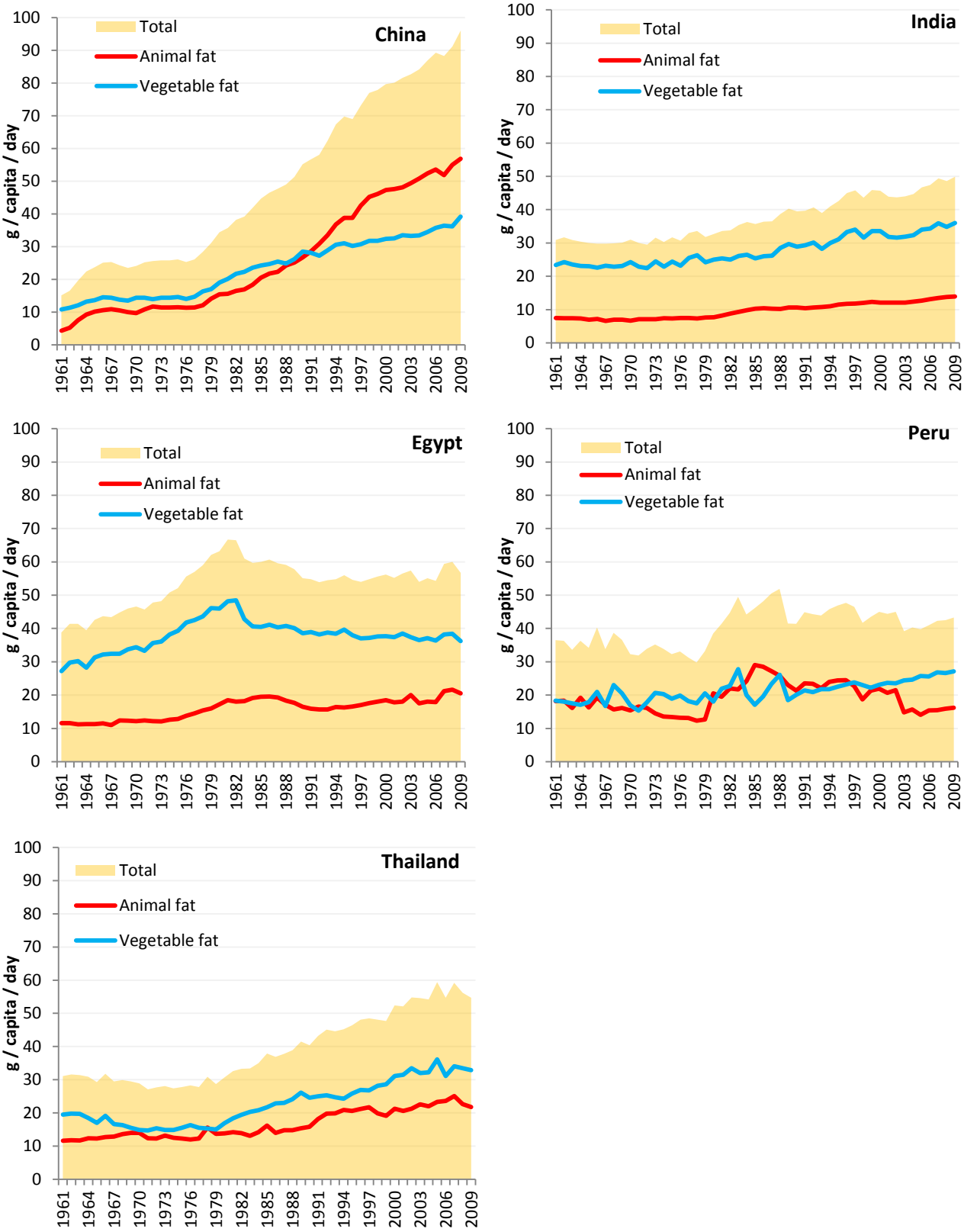
Source: FAOSTAT.

Figure A4.6 Grams of animal and vegetable fat per capita, Oceania, 1961-2009



Source: FAOSTAT.

Figure A4.7 Grams of animal and vegetable fat per capita in case study countries, 1961-2009

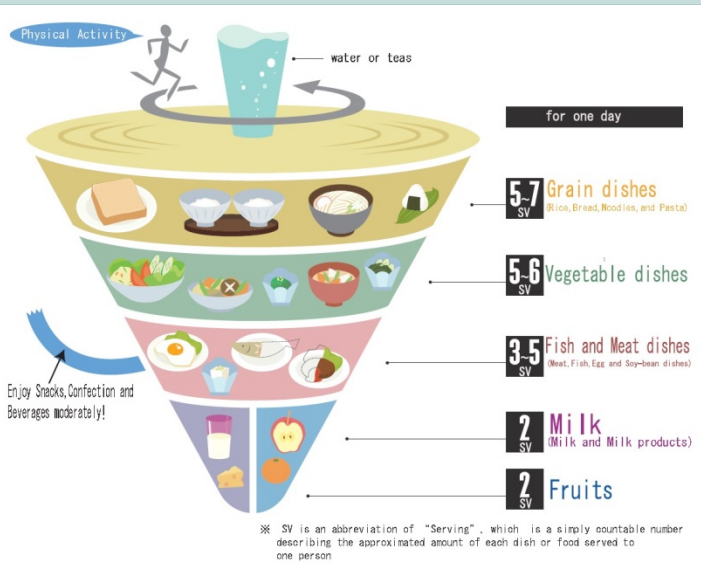


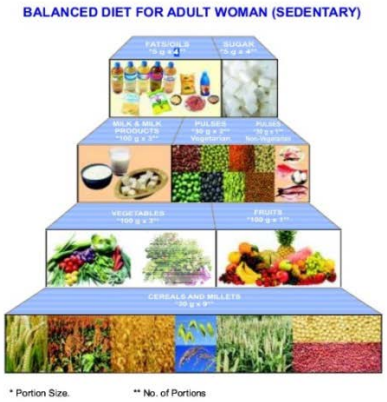
Source: FAOSTAT.

A5: Examples of food guides

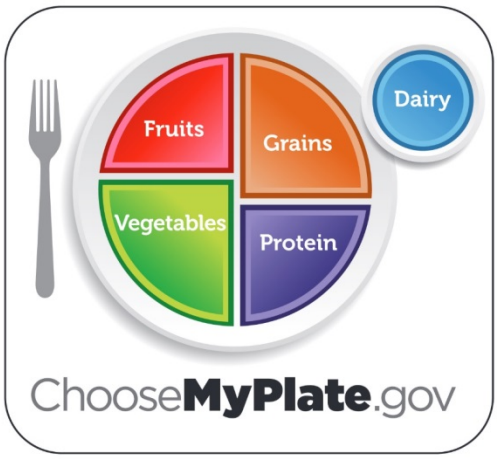
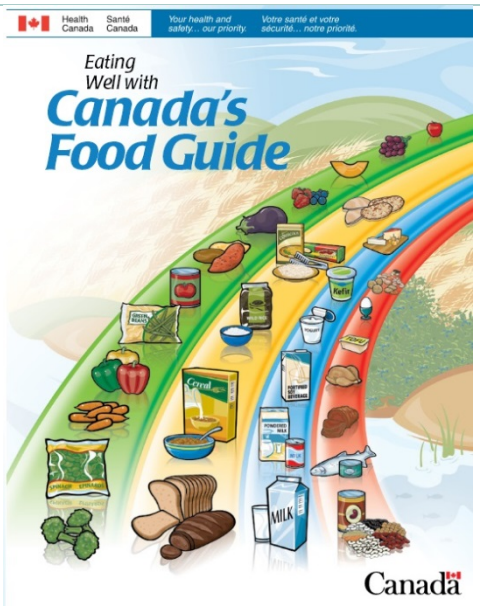
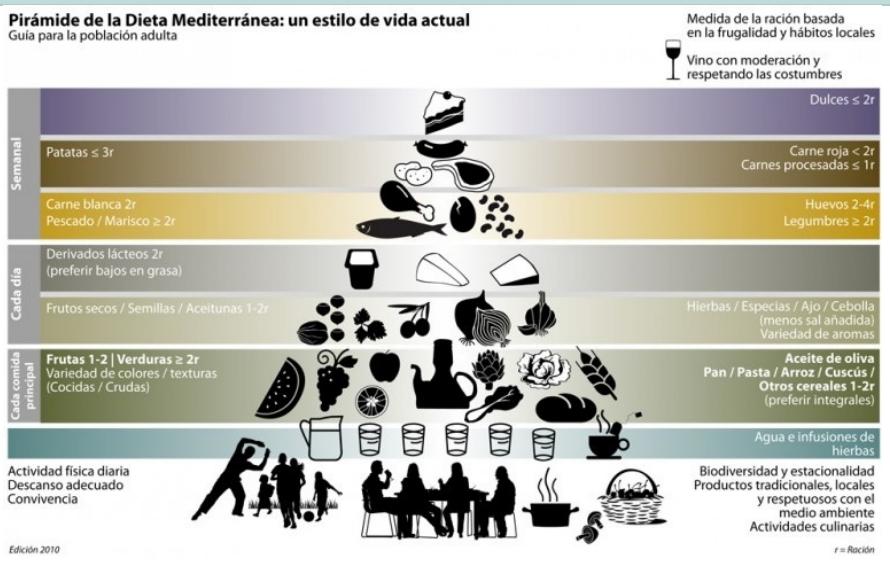
Table A5.1 shows a selection of food guides from around the world

Table A5.1 Examples of graphic food guides

East, SE and S Asia	
Japan **Spinning top** *Source: http://www.mhlw.go.jp/bunya/kenkou/pdf/eiyou-syokuji5.pdf* *Ministry of Health, Labour and Welfare and Ministry of Agriculture, Forestry and Fisheries.*	
China **Food pagoda** Cereals and starchy foods – Fruits and vegetables – fish, poultry, other meat – milk and pulses – salt, sugar, oil. *Source: Chinese Nutrition Society*	

Singapore **Food Pyramid** *Source: Singapore Government* *Health promotion board*	
Philippines **Food Pyramid** *Source: Food & Nutrition Research Institute (FNRI)* *http://www.fnri.dost.gov.ph/index.php?option=com_content&task=view&id=1275&Itemid=162* Adults 20-39. They also have a pyramid for: Children 1-6 years old, Children 7 - 12 years, Teens 13 - 19, Elderly people 60-69, Pregnant women, & Lactating women.	
India **Dietary Guidelines, food pyramid and food stairs** Cereals & millets – vegetables – fruits – pulses – milk & milk products – fats & oils – sugar Also have stairs for men. *Source:* *http://www.ninindia.org/DietaryguidelinesforIndians-Finaldraft.pdf*	Fig. 1 Food Pyramid  

Europe	
United Kingdom **Eatwell plate** *Source: National Health Service, UK.* *http://www.nhs.uk/Livewell/Goodfood/Documents/Eatwellplate.pdf*	
France **Stairs** *Manger Bouger* *Source:* www.mangerbouger.fr	
Americas	
Mexico ***El Plato del Bien Comer*** Vegetables and fruits Cereals – vegetables and fruits – legumes and animal origin foods. *Source: Government of Mexico* *http://www.promocion.salud.gob.mx/dgps/descargas1/programas/1-guia_orientacion_alimentaria.pdf*	

USA **MyPlate** *Source: USDA*	
Canada **Food rainbow** *Source: Health Canada, http://www.hc-sc.gc.ca/fn-an/alt_formats/hpfb-dgpsa/pdf/food-guide-aliment/view_eatwell_vue_bienmang-eng.pdf* *(since 2007)*	
Other	
Mediterranean **Food pyramid** *Source: La Fundación Dieta Mediterránea*	

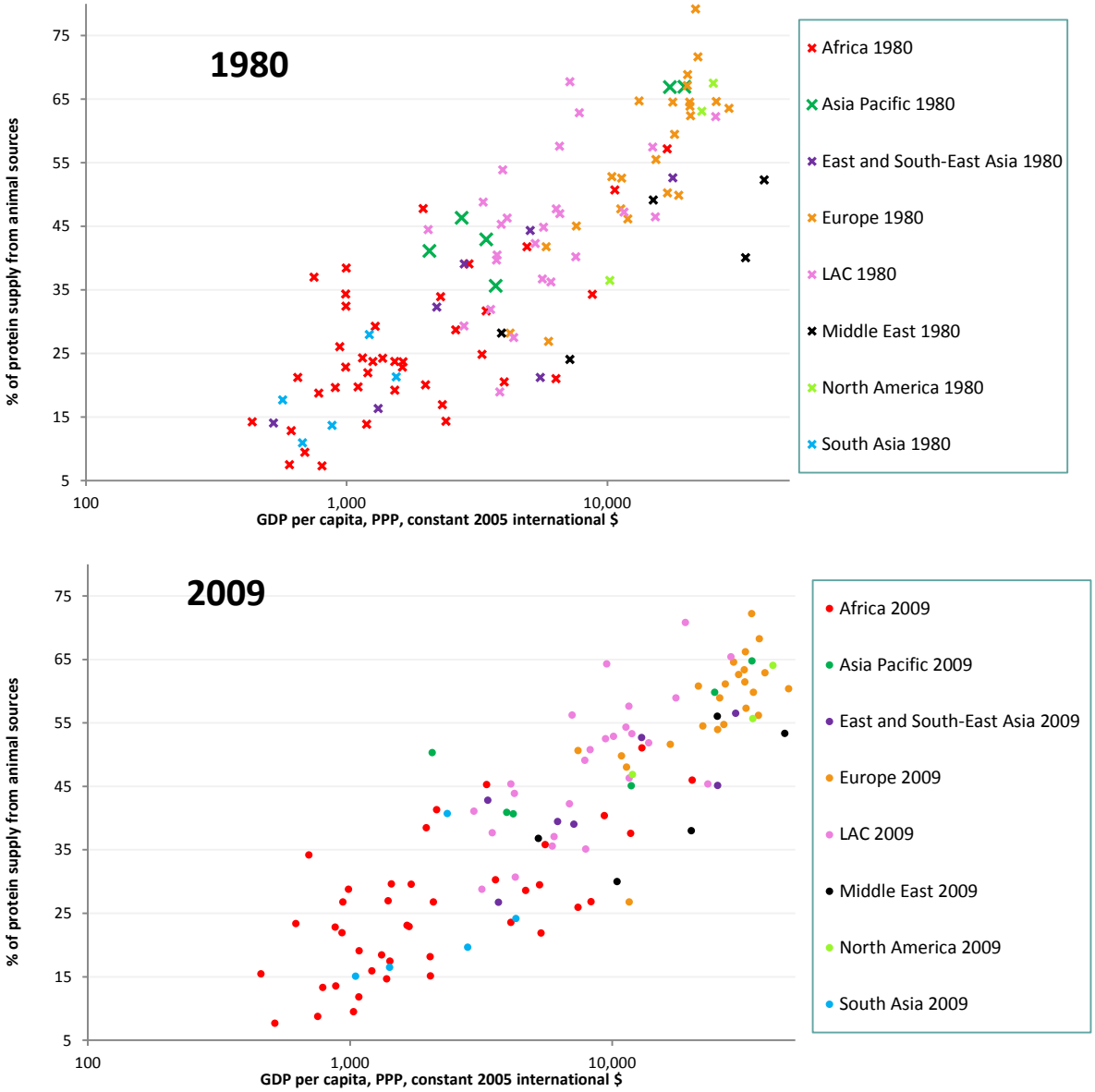
A6: Analysing determinants of animal source protein consumption

A6.1 Proportion of protein from animal sources

How much does income determine the proportion of protein in diets from animal sources? Has this changed from 1980 to recent times? This section looks at these questions

Nationally, plotting the proportion of protein in per capita diets from animal sources against average per capita income (represented by GDP per capita in PPP, constant 2005 $I) shows clearly the expected overall trend: with rising incomes, proportion of protein in average diets supplied by animal sources rises – see Figure A6.1

Figure A6.1 Proportion of protein supply from animal sources compared to national income, 1980 and 2009



Source: Constructed with data from FAOSTAT and World Bank WDI for a total of 228 countries. Note: 2009 is the most recent year for which supply data is available.

Separating the data into values for the year 1980 and the year 2009 and running simple log-linear regressions determining *percent of protein supply from animal sources* using *per capita income* gives adjusted R squares of 0.65 for 1980 and 0.70 for 2009, indicating some 65% to 70% of the variation in proportion of protein supplied from animal sources is explained by income. The equations generated by the regressions are shown below. The strength of the relationship was slightly greater in 1980 than in 2009, as evidenced by the slightly larger coefficient on the income variable (GDP per capita). Both slope coefficients were highly significant.

ln(% protein from animal sources 1980) = 0.36*[ln(GDP per capita)] + 0.51

ln(% protein from animal sources 2009) = 0.34*[ln(GDP per capita)] + 0.63

The relationship between income and animal protein consumption is much stronger at lower income levels—above about $10,000 the relationship begins to level off. For instance, an extra 500 dollars per capita in countries with average incomes of $1,000 would add 4% to 5% to the proportion of protein from animal sources, while an additional 500 dollars at income levels of $20,000 would only add about half a percent to the proportion of protein from animal sources: See Table A6.1

Table A6.1 Predicted animal protein proportions for four income levels, 1980 and 2009

GDP per capita, PPP, constant 2005 international $	% protein from animal sources 1980	% protein from animal sources 2009	Change 1980	Change 2009
500	15.6	15.5		
1,000	20.0	19.7	4.42	4.13
20,000	58.9	54.4		
20,500	59.4	54.9	0.53	0.46

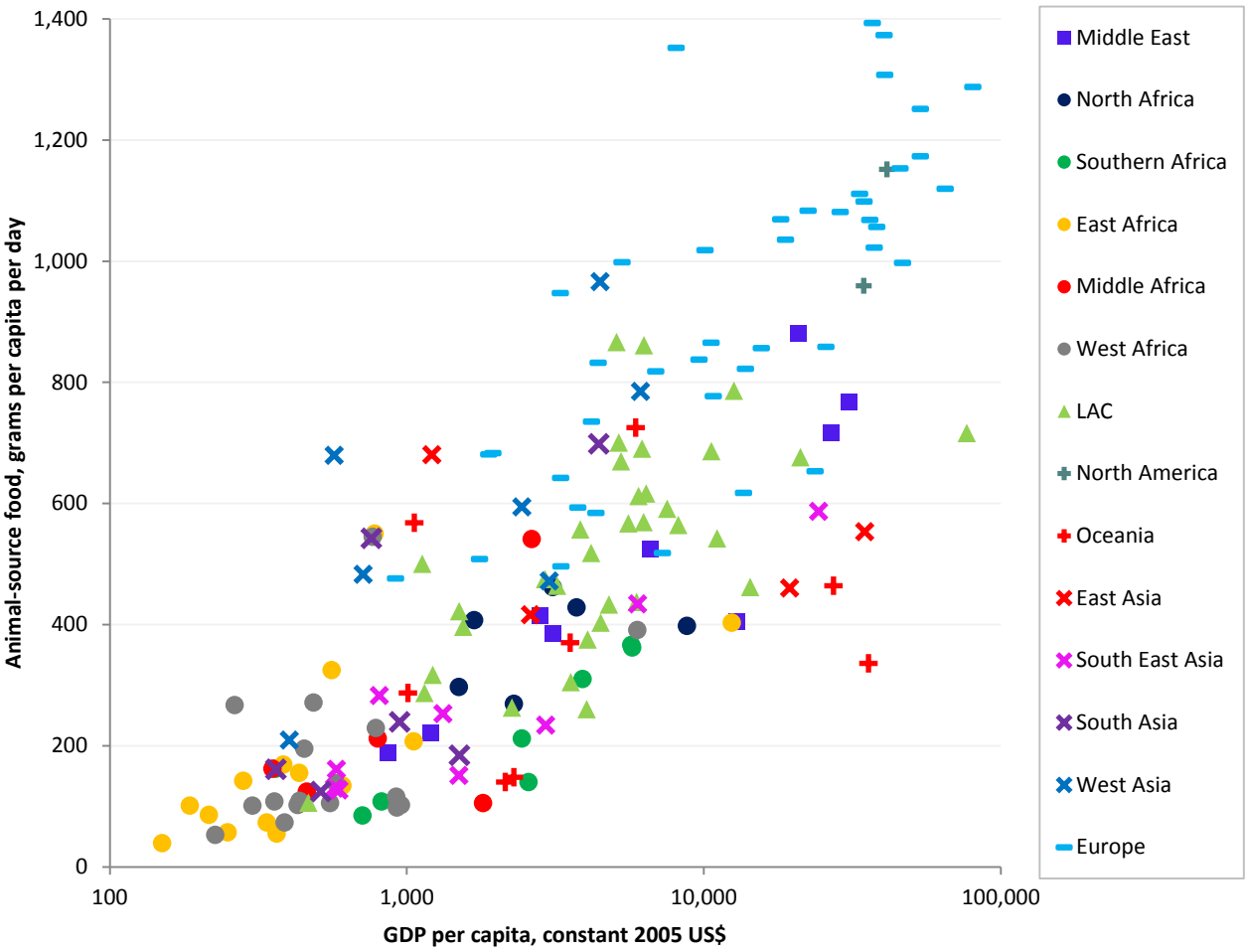
Source: Author calculations

A6.2 Kilograms of protein from animal sources: income and geographic determinants

How important is income in determining how much animal-source foods people eat? Are there differences between different types of animal source foods — meat, milk, and fish & seafood? How does this differ by geographic region? This section examines these questions.

Nationally, plotting the amount of animal-source food in per capita diets against average per capita income (represented by GDP per capita in constant US$2005) shows clearly the expected overall trend: with rising incomes, animal-source food supplied in average diets rises – see Figure A1.1

Figure A6.2 Average per capita animal-source food consumption compared to GDP per capita, 171 countries, 2009

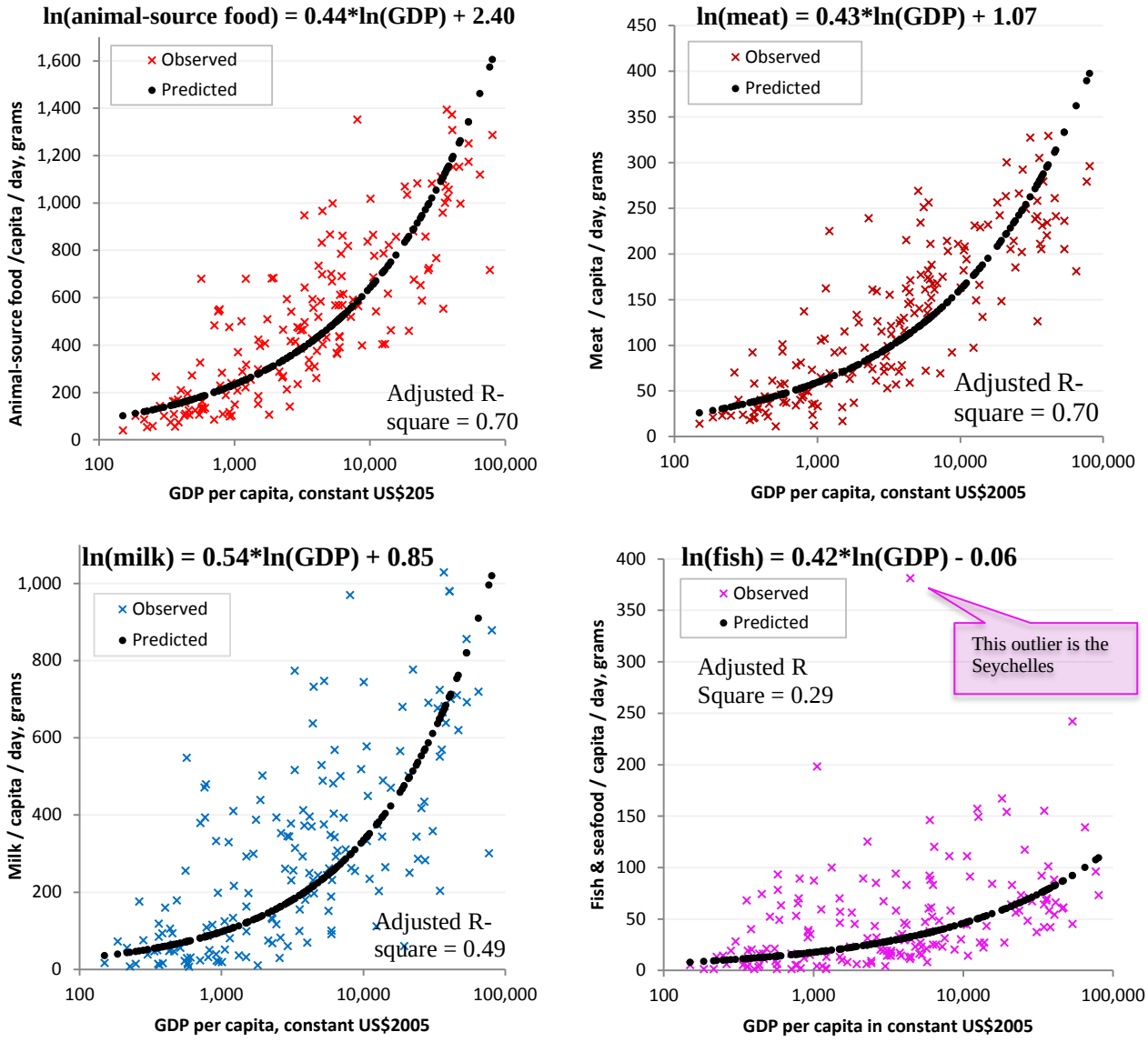


Source: Authors' construction, data from FAOSTAT and World Bank WDI Note: Horizontal axis is a log scale

A simple log-linear regression to predict animal-source food supply using GDP per capita — a proxy for per capita income — gives an adjusted R-square of 0.70, indicating some 70% of the variation in average per capita consumption of animal-source food can be explained by income. The regression equation, predicted, and observed values are displayed in Figure A6.3.

Breaking animal-source food into key constituents, meat, milk, and fish/seafood, and testing each alone as the dependent variable yield slightly different results. Income has a relatively low explanatory power for fish and seafood consumption (adjusted R Square of 0.29), a moderate explanatory power for milk consumption (adjusted R Square of 0.49) and a relatively high explanatory power for meat consumption (adjusted R Square of 0.70). These regression results are also depicted in Figure A6.3. For all of these regressions, coefficients on GDP were highly significant (at least 99%).

Figure A6.3 Observed and predicted values for per capita consumption of all animal-source foods, meat, milk, and fish & seafood at different income levels



Source: Authors' construction using data from FAO and World Bank WDI.

Evident in these figures is the much stronger relationship between income and animal source food consumption at lower income levels—hence the use of the logarithmic scale on the horizontal axis.

Can geography explain some of the remaining variation? Another regression of the data, with dummy variables for regions added to the explanatory power of GDP per capita shows it can. Dummies were included to cover all of the regions in Figure A6.2 with the exception of East Asia. East Asia was chosen as a base region owing to its animal-source food consumption being somewhere in the middle of the distribution. Regressions to determine animal-source food consumption, meat consumption, milk consumption, and fish & seafood consumption showed slightly higher adjusted R Squares when dummies for regions were included. To the multiple regression determining fish & seafood consumption, a dummy for small island nations was also added as this slightly improved explanatory power and was found to be significant. Results of the regressions are shown in Table A6.2.

Table A6.2 Results of multiple determinant regressions

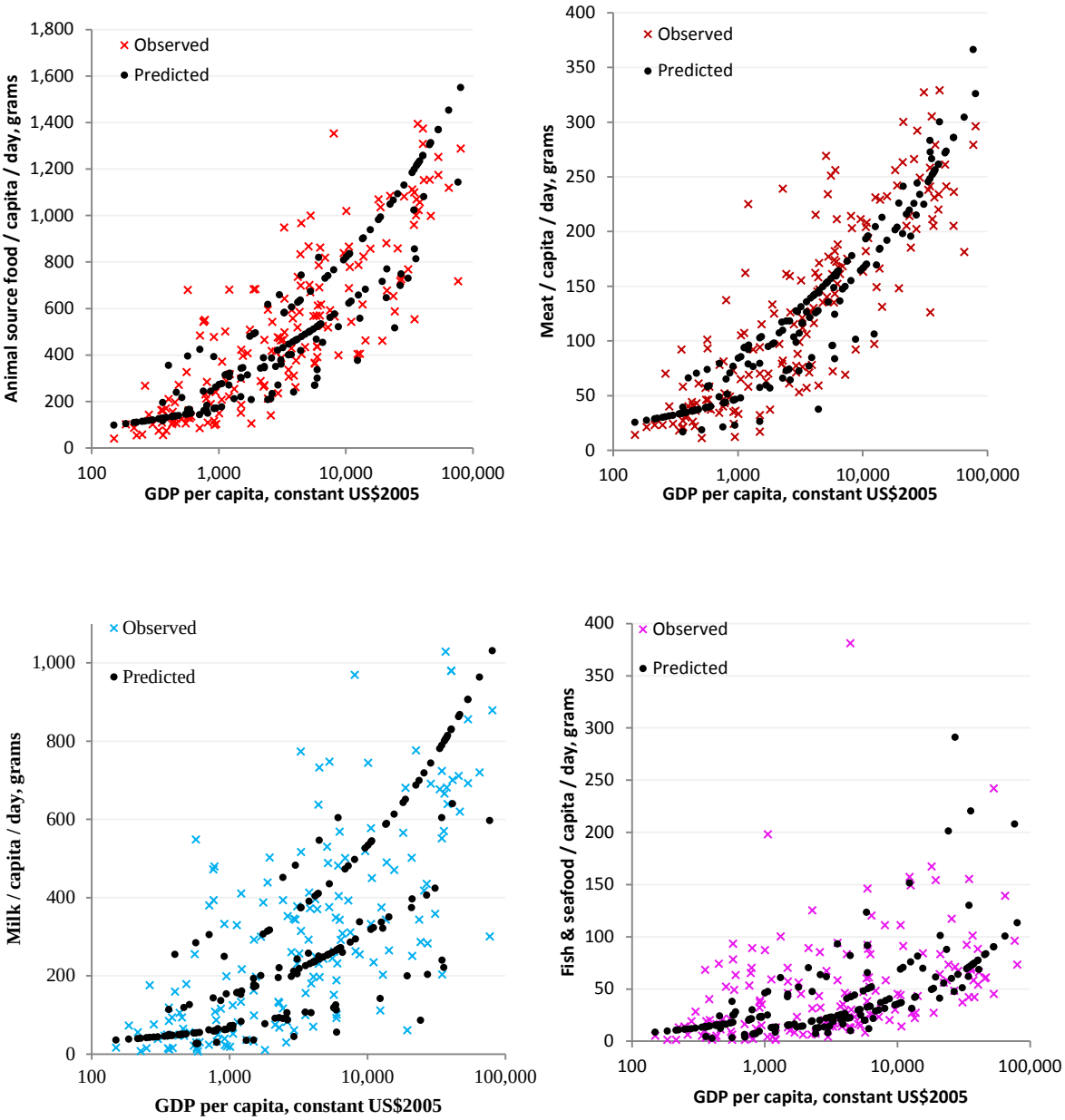
Dependent variable: **Per capita animal product supply**	Adjusted R Square	0.79		
	Observations	171		
		Coefficient	*P-value*	*Significance*
	Intercept	3.54	0.000	***
	ln GDP	0.31	0.000	***
	South East Asia	-0.40	0.085	*
	South Asia	-0.08	0.739	
	West Asia	0.49	0.041	**
	East, West, Middle Africa	-0.51	0.016	**
	Southern Africa	-0.60	0.010	**
	North Africa	-0.07	0.761	
	Middle East	-0.12	0.581	
	Europe	0.34	0.088	*
	North America	0.18	0.581	
	LAC	0.05	0.814	
	Oceania	-0.06	0.793	
Dependent variable: **Per capita meat supply**	Adjusted R Square	0.80		
	Observations	171		
		Coefficient	*P-value*	*Significance*
	Intercept	2.23	0.000	***
	ln GDP	0.32	0.000	***
	South East Asia	-0.22	0.335	
	South Asia	-1.32	0.000	***
	West Asia	0.02	0.920	
	East, West, Middle Africa	-0.61	0.003	***
	Southern Africa	-0.46	0.043	**
	North Africa	-0.54	0.023	**
	Middle East	-0.16	0.482	
	Europe	-0.09	0.633	
	North America	0.04	0.900	
	LAC	0.04	0.839	
	Oceania	-0.03	0.888	
Dependent variable: **Per capita milk supply**	Adjusted R Square	0.68		
	Observations	171		
		Coefficient	*P-value*	*Significance*
	Intercept	2.16	0.000	***
	ln GDP	0.32	0.000	***
	South East Asia	-0.92	0.027	**
	South Asia	0.70	0.120	
	West Asia	1.48	0.001	***
	East, West, Middle Africa	-0.20	0.597	
	Southern Africa	-0.13	0.750	

	North Africa	0.78	0.076	*
	Middle East	0.61	0.134	
	Europe	1.20	0.001	***
	North America	0.93	0.117	
	LAC	0.66	0.065	*
	Oceania	-0.09	0.832	
Dependent variable: **Per capita fish & seafood supply**	Adjusted R Square	0.46		
	Observations	171		
		Coefficient	*P-value*	*Significance*
	Intercept	-1.42	0.056	*
	ln GDP	0.56	0.000	***
	South East Asia	1.07	0.051	*
	South Asia	0.69	0.243	
	West Asia	-1.01	0.077	*
	East, West, Middle Africa	0.73	0.144	
	Southern Africa	-0.44	0.427	
	North Africa	0.03	0.952	
	Middle East	-0.44	0.413	
	Europe	-0.18	0.705	
	North America	-0.31	0.693	
	LAC	0.03	0.957	
	Oceania	0.94	0.093	*
	Island = 1	0.43	0.039	**

Source: Authors' construction using data from FAO and World Bank WDI.

Even with regional dummies and a dummy for islands added, fish and seafood consumption remains the most difficult to explain. Figure A6.4 shows the observed and predicted results of the multiple regressions.

Figure A6.4 Observed and predicted results of the multiple determinant regressions

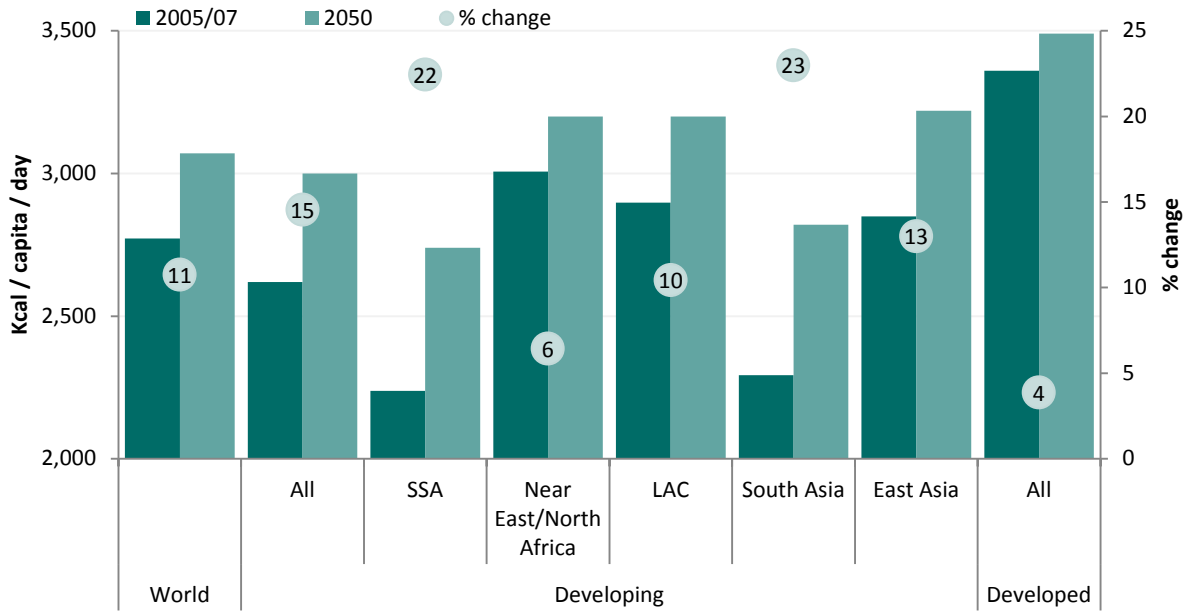


Source: Authors construction using data from FAOSTAT and World Bank WDI

A7: Additional detail on future diet projections

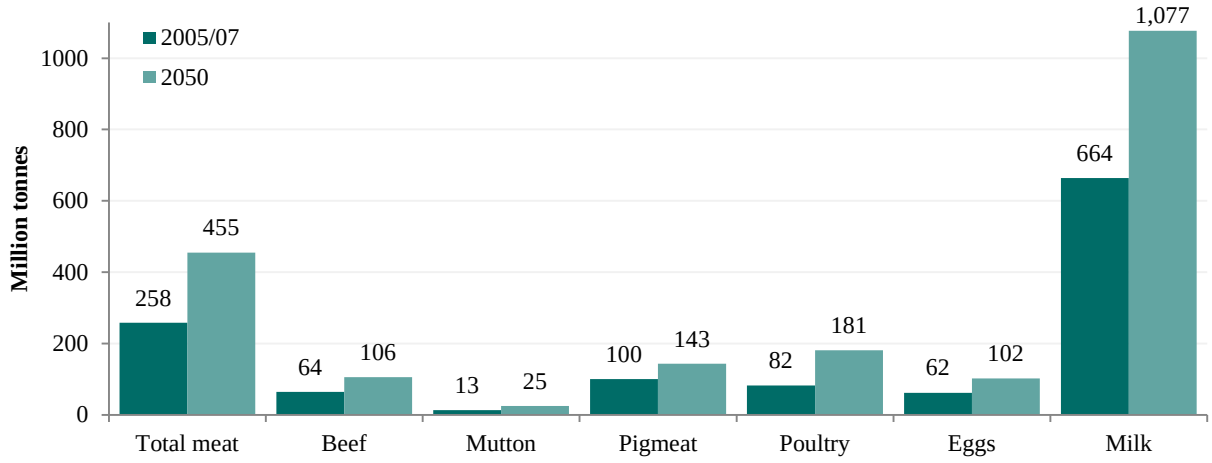
The following figures provide some additional detail on projections of food energy supply to 2050, animal food consumption in kilograms per capita, sources of growth in crop production, and projected fertiliser consumption.

Figure A7.1 Food energy supply per capita by region, 2005/07 and projected to 2050



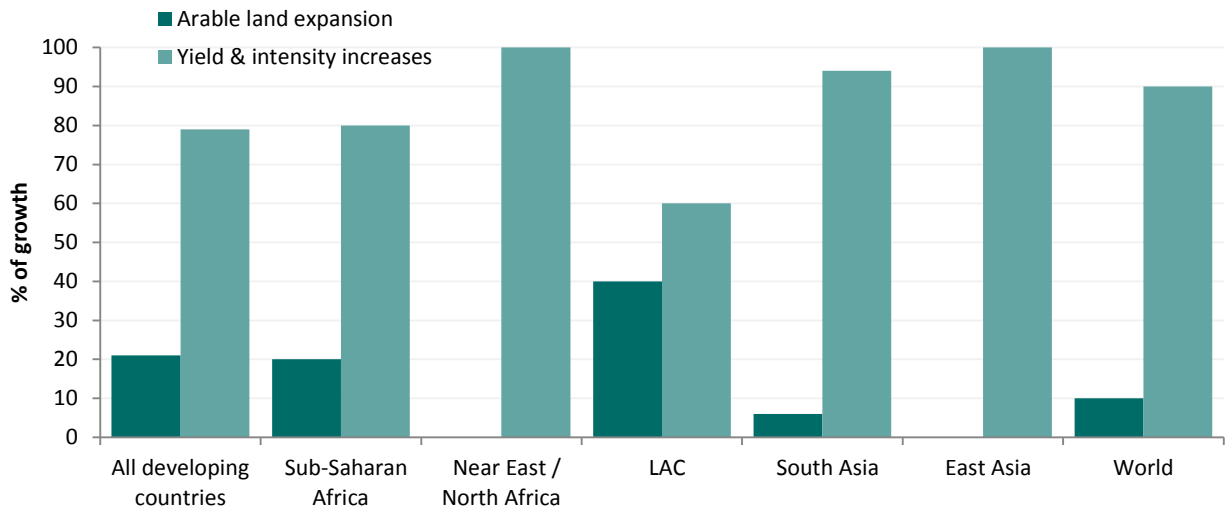
Source: Table 2.1 in Alexandratos & Bruinsma, 2012

Figure A7.2 Kilos of terrestrial animal food supply per capita, by type, 2005/07 to 2050



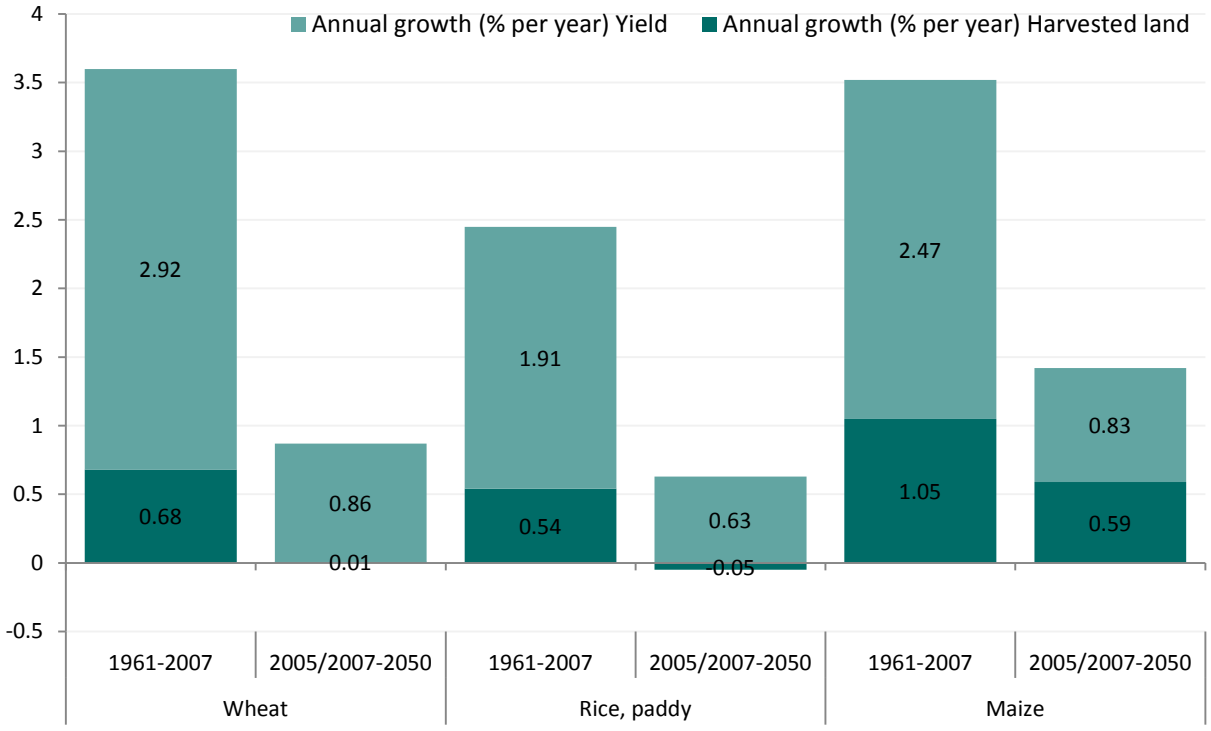
Source: Data from Table 4.18 in Alexandratos & Bruinsma, 2012.

Figure A7.3 Developing world, sources of growth in crop production, %, 2005/07 to 2050



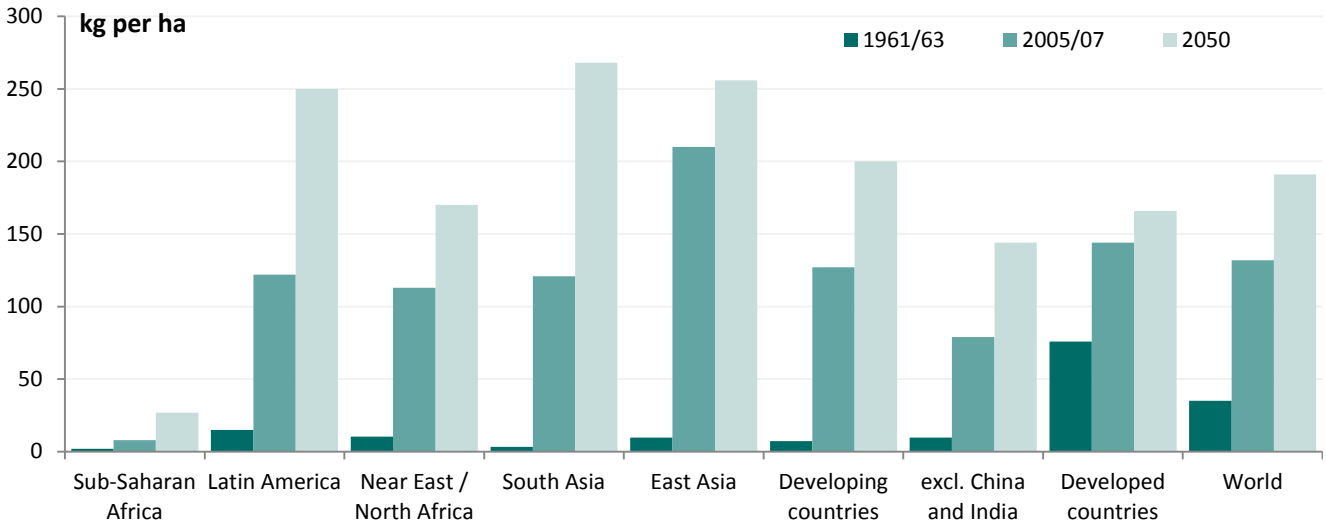
Source: Table 4.4 in Alexandratos & Bruinsma, 2012.

Figure A7.4 Average annual growth (% per year) in yield and land area for the 3 main cereals, 1961-2007 and 2005/07 to 2050



Source: Table 4.5 in Alexandratos & Bruinsma, 2012.

Figure A7.5 Fertiliser consumption: historical and projected



Source: Table 4.15 in Alexandratos & Bruinsma, 2012

Table A7.1 Extra grain required to meet per capita meat consumption estimates in China in 2050 if 2005/07 figures used in original projections are overestimated by 6.8kg per capita

	2005/07 (Alexandratos & Bruinsma, 2012)	2005/07 (Lower estimate for meat consumption, 70% of FAOSTAT)	2050 (Alexandratos & Bruinsma, 2012)
Population estimates, China (millions)	1,315	1,315	1,296
Kg meat / capita (Alexandratos & Bruinsma 2012)	44.3	37.5	71.1
M tonnes of meat total, China (A&B 2012)	58.3	49.3	92.1
Conversion ratio	4 to 1	4 to 1	4 to 1
Meat total as grain, M tonnes	233.0	197.3	368.6
	Original A&B 2012 estimate	**Lower 2005/07 estimate**	
Change in Grain equivalent, 2005/07 to 2050, M tonnes	135.6	171.3	
Change across the 2 estimates, MT			35.8

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