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Research report

Food consumption patterns and economic growth. Increasing affluence and the use of natural resources

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ABSTRACT

This study analyzes relationships between food supply, consumption and income, taking supply, meat and dairy, and consumption composition (in macronutrients) as indicators, with annual per capita GDP as indicator for income. It compares food consumption patterns for 57 countries (2001) and gives time trends for western and southern Europe. Cross-sectional and time series relationships show similar patterns of change. For low income countries, GDP increase is accompanied by changes towards food consumption patterns with large gaps between supply and actual consumption. Total supply differs by a factor of two between low and high income countries. People in low income countries derive nutritional energy mainly from carbohydrates; the contribution of fats is small, that of protein the same as for high income countries and that of meat and dairy negligible. People in high income countries derive nutritional energy mainly from carbohydrates and fat, with substantial contribution of meat and dairy. Whenever and wherever economic growth occurs, food consumption shows similar change in direction. The European nutrition transition happened gradually, enabling agriculture and trade to keep pace with demand growth. Continuation of present economic trends might cause significant pressure on natural resources, because changes in food demand occur much faster than in the past, especially in Asia.

Introduction

At present, the world faces enormous challenges over food security (Millenium Ecosystems Assesment, 2005), which threaten the availability and quality of natural resources such as arable lands, freshwater and natural areas (FAO, 2003; Hoekstra & Chapagain, 2008; WWF, 2007). The potential impacts of climate change are likely to worsen this situation (Fischer, Van Velthuizen, Shah, & Nachtergaele, 2002). Globally, food consumption gives rise to the greatest use of land (FAO, 2003; Penning de Vries et al., 1995) and freshwater (Falkenmark, 1989; FAO, 2003; Hoekstra & Chapagain, 2008; Rockstrom, 1999; Rosegrant & Ringler, 1998) and is an important cause of greenhouse gas emissions (Carlsson-Kanyama, Engström, & Kok, 2005; Kramer, 2000). The current growth in the world population requires the production of more food. As well as population growth, most areas of the world have shown economic development that resulted in increased purchasing power, causing not only a demand for more food (Latham, 2000) but also for different food. Studies on human nutrition have shown that worldwide a nutrition transition is taking place, in which people shift towards more affluent food consumption patterns (FAO, 2003; Grigg, 1995; Popkin, 2002). Globalization of nutrition includes shifts from local markets towards global trade in commodities and processes in which people and ideas spread throughout the world (Lang, 2002) and thereby change consumption. Since the beginning of the eighteenth century, the nutrition transition that accompanied economic development has caused large shifts in food consumption patterns in Europe and the United States (Fogel & Helmchen, 2002). When economic development occurs in developing countries as well, as is the case in China today (IMF, 2010), nutritional changes put additional pressure on limited natural resources.

The use of natural resources for food is the combined effect of a specific consumption pattern and production system. Several scientists describe the complex links between sustainable consumption and the limited availability of natural resources (e.g. Hertwich, 2005). Duchin (2005) provides an overview of studies on energy and land required for food and suggests that a shift from affluent consumption patterns towards a Mediterranean-type pattern, characteristic of Greece in the 1960s, has favorable impacts on the environment.

Abbreviations: A%, average supply of nutritional energy from animal sources (%); E%, energy percentage; FAO, Food and Agriculture Organization of the United Nations; GDP, gross domestic product; GE, grain equivalents; G-K dollars, 1990 International Geary-Khamis dollars; PPP, purchasing power parity; WHO, World Health Organization.

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Agriculture is the basis for the production of food, providing commodities such as wheat and raw milk. The number of agricultural commodities that are important for the global supply of food is limited to about 21 when expressed in terms of weight of annual global production (FAO, 2010). The 15 main categories of crop commodities, expressed as annual global production (kg), are sugar cane, root crops, vegetables, maize, paddy rice, wheat, fruits, potato, sugar beet, cassava, soybean, barley, pulses, oil seed rape and sorghum; the six main animal commodities are raw milk, pork, poultry, beef, mutton and goat's meat (FAO, 2010). These commodities provide the ingredients for a large number of different food items, such as pizza or cheese. The mass of food items mainly consists of only four different components: water and the three macronutrients carbohydrates, fats and proteins (FAO, 2010; Voedingscentrum, 1998a, 1998b; Whitney & Rolfes, 1999). Food items form the basis of food consumption patterns, defined as the consumption of specific food items and their combination in dishes and meals. These patterns show large temporal and spatial differences, mainly caused by the availability of commodities, cultural aspects and economic factors (Whitney & Rolfes, 1999). The requirements for specific natural resources for each food item are determined by the production system. In general, food items show large differences in the requirement for land (Gerbens-Leenes & Nonhebel, 2005), energy (Kramer, 2000) and freshwater (Hoekstra & Chapagain, 2007), resulting in substantial variations in requirements for natural resources between food consumption patterns. As a rule, affluent western-style food consumption patterns need more natural resources than those of poor developing countries (e.g. Duchin, 2005; Gerbens-Leenes & Nonhebel, 2002; Hoekstra & Chapagain, 2007). Food items that are typical of affluent patterns are fats, drinks and foods derived from animal sources, such as milk, cheese and meat. These items have a substantial impact on natural resources, either through heavy consumption (for example of beer), or through large specific resource requirements per unit of food. For example, in western countries the contribution of fats to land requirements is about 25% and that of meat about 30% (Gerbens-Leenes & Nonhebel, 2002), while the contribution of meat to energy and freshwater requirements is also about 30% (Gerbens-Leenes & Hoekstra, 2007; Kramer, 2000). It is therefore important to identify the relationship between economic growth and more affluent food consumption patterns.

Hundreds of detailed studies from the nutritional, social and agricultural sciences, as well as food security studies, are available. Nutritional and social studies express consumption in terms of specific food items (e.g. Mennell et al., 1992; Receveur, Boulay, & Kuhnlein, 1997; Whitney & Rolfes, 1999), agricultural studies on global food security simplify consumption to basic and affluent diets and show them in grain equivalents (GE) (e.g. Penning de Vries et al., 1995), while other studies address food security as the average per capita availability of commodities (FAO, 2003). The agricultural and food security studies often show time trends, emphasizing the need to increase agricultural production. The effect of income on food consumption patterns is recognized as one of the factors that determine food choice (e.g. Van der Boom-Binkhorst et al., 1997; Von Braun, 1988; Von Braun & Paulino, 1990; Ivens et al., 1992; Musaiger, 1989; Vringer & Blok, 1995; Wandel, 1988; Whitney & Rolfes, 1999; De Wijn & Weits, 1971). Among the poorest people, be they individuals or nations, diets tend to be composed principally of cheap starchy staple foods: wheat, rice, potatoes, cassava and the like (Jobse-van Putten, 1995; Poleman & Thomas, 1995). Existing research often focuses on health issues and changes in time. General relationships between economic change and the rate of change in food consumption patterns are also important to be explored.

The nutrition transition began in developed countries 300 years ago. It coincided with great economic growth (Maddison, 2003). If developing countries follow the same route, it would mean a major shift in the balance between global food demand and supply, with considerable consequences for natural resources. It is therefore important to investigate whether there are general relationships between economic growth and food consumption patterns. This is also important when growth is negative. The FAO, for example, estimated that in 2007 75 million people were pushed into undernourishment as a result of higher food prices mainly caused by an increase in commodities used for bio-energy, bringing the total number of hungry people in the world to 923 million (FAO, 2008). It is possible that the current financial crisis will diminish purchasing power and so increase the risk of a drop in food intake.

When food consumption patterns are expressed in terms of food items, differences among the patterns are large and studying them requires a great amount of data and time. This paper presents an analysis of nutritional changes due to economic growth, so being situated between detailed consumption pattern analyses in terms of specific foods items, which are only valid for a limited group of consumers, and the coarse agricultural analyses based on simplified diets in terms of GE. The paper expresses changes in terms of macronutrients and related nutritional energy. The specific aims of this study are to quantify shifts in food consumption patterns that accompany economic development. The research questions are: (i) what are the trends in national per capita food supply, measured in terms of nutritional energy and macronutrients that follow economic changes? (ii) what are the trends in individual per capita food consumption, i.e. the food actually eaten, measured in terms of nutritional energy and macronutrients, that accompany economic changes? (iii) in which regions will large changes in food supply and consumption occur in the next 10 years? To analyze the impact of economic changes on food consumption patterns this study addresses similarities among patterns in terms of composition, rather than differences in terms of food items. This approach makes it possible to identify general trends. By differentiating between national per capita supply and individual consumption, it also shows trends for the gap between supply and consumption. The study analyzes cross-sectional and time series relationships, revealing general trends. These trends provide a better understanding of the connection between food consumption and environment and can contribute to environmental studies that aim to indicate transition pathways towards a more sustainable use of natural resources.

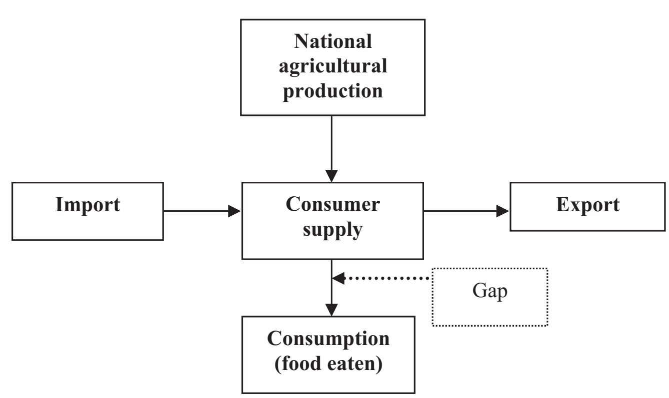

Fig. 1. Simplified food system overview. Consumer supply is defined as per capita national food availability and is a function of national production + import − export. Consumption is food actually eaten. The difference between supply and consumption is the gap caused by food chain losses.

Food systems

Food systems include production and related supply of commodities and foods as well as consumption, defined here as the food actually eaten. Figure 1 shows a simplified overview of the system. Agricultural production provides crop and animal commodities. On a national level, supply is a function of national production plus imports minus exports. Consumer supply is defined here as the per capita national availability of food, consumption as actual consumed food. The difference between supply and consumption is the gap caused by losses in the food chain.

Production

Starting in 1961, FAO food balance sheets (FAO, 2010) provide information for almost all countries in the world on the annual market supply of agricultural commodities. The food industry selects and processes agricultural commodities to manufacture food items (Catsberg & Kempen-van Dommelen, 1997). It often divides commodities into several fractions based on composition characteristics, such as the fat, protein or carbohydrate content (the macronutrients). The fractions form the basic ingredients for food items, when industry joins in and processes ingredients. Soybeans, for example, are split into an oil and an oil cake fraction (Kramer & Moll, 1995). Oil is a basic ingredient in margarines, oil cake in livestock feed. In the western world, technological developments in agriculture, transportation and food conservation at the end of the 19th century prompted the expansion of the food industry and food preparation shifted from households to industry (Jobse-van Putten, 1995), so stimulating the nutrition transition.

Figure 1 shows that agriculture, inside or outside the national borders, determines consumer supply available for consumption. Sometimes wastes are reused, for example manure or waste from the food industry for livestock feed (Nonhebel, 2004). In every link of the system losses take place. For example, the food industry processes 1.4 kg of wheat to manufacture 1 kg of flour (Kramer & Moll, 1995). A study on household consumption in Sweden has estimated that during meals 10% of the food remains behind on the plate and is wasted (Karlsson, 2001). These losses cause a gap between consumer supply and consumption, i.e. the food actually eaten.

Consumption

Consumer supply concerns the food available for consumption at a national level. Consumers buy it in shops or sometimes produce it in their gardens (Fernandes & Nair, 1986; Pallot & Nefedova, 2003). The repeated arrangements of consumption, characterized by types and quantities of food items and their combination in dishes and meals, are termed food consumption patterns (Gerbens-Leenes & Nonhebel, 2002). Factors such as preferences, habits, availability, tradition, culture and income influence these patterns (Van der Boom-Binkhorst et al., 1997; Von Braun, 1988; Von Braun & Paulino, 1990; Ivens et al., 1992; Musaiger, 1989; Vringer & Blok, 1995; Wandel, 1988; Whitney & Rolfes, 1999; De Wijn & Weits, 1971). For instance, when income increases, people spend more money on food (Pindyck & Rubinfeld, 2005; Vringer & Blok, 1995).

Consumption, or human nutrition, concerns the food actually eaten. For nutrition the composition of food in terms of macronutrients, its fats, carbohydrates and proteins, is important, because they provide energy and are essential for the functions of the human body. Food surveys ask respondents what they have eaten and provide detailed information on the composition of consumed food (see also Appendix B). Humans can derive energy from different combinations of macronutrients. This flexibility contributes to variations in the macronutrient composition of nutrition and to differences in food consumption patterns.

The composition of food

Four components, water, carbohydrates, fats and proteins, dominate the composition of every commodity (FAO, 2010; Voedingscentrum, 1998a, 1998b; Whitney & Rolfes, 1999). The macronutrient content of commodities, such as wheat, soybean or pork, is genetically determined, so that all crop and animal commodities show a specific composition (kg macronutrient per kg dry matter) (Penning de Vries et al., 1989; Schmidt-Nielsen, 1988). Based on composition, commodities form four categories: (i) *starchy staples*, crops that mainly provide carbohydrates with few proteins; (ii) *protein-rich crops*, which provide proteins as well as carbohydrates; (iii) *oil crops*, providing plant-based fats for the production of oil, and carbohydrates and proteins for feed (Penning de Vries et al., 1989); and (iv) *animal commodities*, which provide high quality proteins and fats (Whitney & Rolfes, 1999). The composition of a commodity determines its suitability for a food item (Whitney & Rolfes, 1999). For example, starchy staples, such as wheat, can be used for bread or pasta, while oil crops, such as oil seed rape, provide oil (Voedingscentrum, 1998a, 1998b) for margarines. Consumption changes can cause shifts in the macronutrient composition of food consumption patterns including a demand for different commodities.

The food system and natural resources

Several studies have shown that natural resource use varies greatly between food items and food consumption patterns (e.g. Engelenburg van, Rossum van, Blok, & Vringer, 1994; Hoekstra & Chapagain, 2008; Kok, Biesiot, & Wilting, 1993; Kramer & Moll, 1995; Tukker & Jansen, 2006). Meat, fats, and drinks especially have relatively large requirements for energy, land and freshwater (MJ kg^{-1}, $m^2\,kg^{-1}$, $m^3\,kg^{-1}$). One kilogram of pork providing 2000 kilocalories (Voedingscentrum, 1998a, 1998b), for example, requires 86 MJ of energy (Kramer & Moll, 1995), 9 m^2 of land (Gerbens-Leenes & Nonhebel, 2005) and 4850 L of freshwater (Hoekstra & Chapagain, 2008) for its production. In comparison, 1 kg of paddy rice providing even more nutritional energy (3500 kilocalories) requires 22 MJ energy (Kramer & Moll, 1995), 3 m^2 land (Gerbens-Leenes, 2006) and 2300 L of water (Hoekstra & Chapagain, 2008). The example shows that changes in food consumption patterns can have a considerable impact on natural resource use.

Methods and data

To analyze the relationship between food supply, food consumption, and the contribution of animal foods to supply on the one hand and income on the other, this study assesses cross-sectional and time series relationships.

Units of calculation

The study does not express food supply and consumption in terms of foods, but simplifies supply and consumption and uses macronutrient composition (fats, carbohydrates and proteins) as units of calculation. It indicates per capita food supply in the fraction of nutritional energy provided by the macronutrients, the macronutrient energy percentage (*E*%), as is common in nutrition research (Whitney and Rolfes, 1999). It shows the contribution of animal foods to supply in the fraction of nutritional energy derived from animal sources (*A*%), and total food supply as availability of nutritional energy (kilocalories per capita per day). *E*% and *A*% are calculated by

$$\text{protein}\,E\% = \frac{P \times kcal.\,p}{E} \times 100\% \tag{1}$$

$$\text{fat}\, E\% = \frac{F \times kcal.f}{E} \times 100\% \quad (2)$$

$$\text{carbohydrate}\, E\% = \frac{E - ((P \times kcal.p) + (F \times kcal.f))}{E} \times 100\% \quad (3)$$

$$A\% = \frac{A}{E} \times 100\% \quad (4)$$

where *P* is the average daily supply of protein (grams), *kcal.p* the nutritional energy supply of protein (4 kilocalories per gram), *E* the average daily per capita supply of nutritional energy (kilocalories), *F* the average daily supply of fat (grams); *kcal.f* the nutritional energy supply of fat (9 kilocalories per gram) and *A* the average daily per capita supply of nutritional energy from animal sources (kilocalories). The study derives data on per capita supply from FAO food balance sheets (FAO, 2010) and values on nutritional energy for protein and fat from the Dutch Nutrition Council (Voedingscentrum, 1998a, 1998b).

Average per capita income depends, among other things, on the development status of an economy, the size of households and income distribution in a country. The World Bank (2005) calculates economic output as gross domestic product (GDP). Information on average per capita GDP is available for most countries from various sources. The only database, however, that covers recent information on GDP as well as historical economic developments is that of Maddison (2003) which provides information on the economic development status of almost all countries in the world on a national and per capita basis from the Middle Ages onwards. It expresses average GDP in 1990 International Geary-Khamis dollars (G-K dollars). The Geary-Khamis method is an aggregation method in which international prices and a countries purchasing power parity, depicting relative country price levels, are estimated simultaneously from a system of linear equations and expressed in G-K dollars (United Nations Statistics Division, 2006). We derive data on per capita GDP from Maddison (2003) as an indicator for income (expressed as dollars per capita per year) for the cross-sectional and time series relationships.

Cross-sectional relationships

The study assesses cross-sectional relationships between income and food supply, the contribution of animal foods and the composition of supply for 57 countries in 2001. Appendix A gives an overview of these countries. Countries from Africa, Asia, Eastern Europe, Latin America, the Middle East and the OECD, in different stages of development and with more than five million inhabitants, have been selected. These countries form two clusters of developed and developing countries, with relatively high and relatively low GDPs, however. To also cover countries with average incomes, three small transition countries with GDPs in between the two extremes, the United Arab Emirates, Estonia and Slovenia, are added, clustered into a small country group.

Time series relationships

Over the last millennium Europe has shown continuous economic growth (Maddison, 2003). Between 1700 and 2000, for example, per capita GDP in France increased from 900 to 21,000 dollars and in Great Britain from 1250 to 20,000 dollars. Between 1961 and 2001, Italy, Greece, Spain and Portugal showed a three- to fourfold increase of per capita GDP. These periods were accompanied by large changes in food consumption patterns (Jobse-van Putten, 1995; FAO, 2010; Fogel & Helmchen, 2002). Most studies of historical food consumption describe changes in a qualitative way (e.g. Jobse-van Putten, 1995; Mennell et al., 1992) and do not provide quantitative data. An exception is the analysis by Fogel and Helmchen (2002), which has quantified nutritional energy supply for France and Great Britain between 1700 and 2000 (kilocalories per capita per day). To evaluate per capita food supply over time, this study first assesses a time series relationship between supply and income in France and Great Britain over a period of three centuries. It combines data from Fogel and Helmchen (2002) with GDP data from Maddison (2003).

Secondly, the study evaluates a four-decade time series relationship in southern Europe. For Italy, Spain, Portugal and Greece, it assesses the relationship between the increase of per capita supply, changes in the composition of food consumption and changes in the contribution of animal foods on the one hand and income on the other over the period 1961–2001. It applies Eqs. (1)–(4) and derives data from the FAO (2010) and combines this with data on GDP from Maddison (2003).

Confirmation of trends and the gap between supply and consumption

This study firstly assesses the relationship between GDP and national per capita food supply. Secondly, to evaluate whether information from food surveys can confirm trends found, the study assesses the relationship between consumption, expressed as nutritional energy intake (kilocalories per capita per day), and annual per capita GDP. A number of surveys have been done in developing countries (FAO, 2005) and two time series are available for developed countries, the Netherlands (Voedingscentrum/TNO, 1998) and the United States (USDA, 2005). The study combines data from 31 food surveys from 26 countries (see Appendix B) with information on GDP from Maddison (2003). Thirdly, it evaluates the size of the gap between national per capita supply and consumption. This provides information on food losses in the supply chain. To confirm trends, the study also compares the fat *E*% of urban and rural consumption. Data for this were derived from 11 surveys in developing countries that made a distinction between urban and rural patterns (see Appendix B).

Results and discussion

Per capita income and food supply

The cross-sectional analysis indicates a relationship between per capita food supply and income (GDP) following a power-law dependency $E = 850 \times \text{GDP}^{0.14}$, thus showing an income elasticity of about 0.14. Figure 2 shows that supply varies between 1600

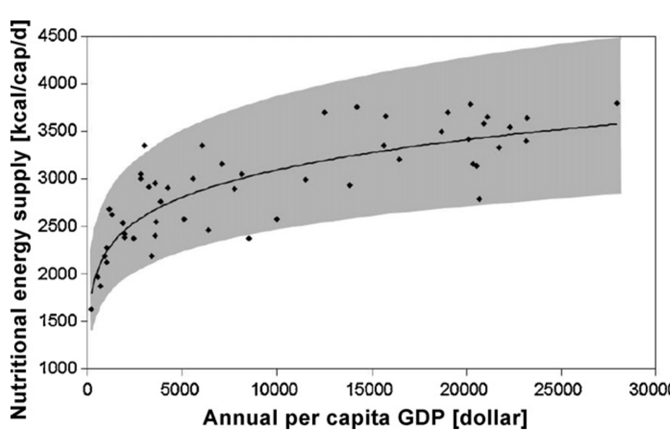

Fig. 2. Relationship between annual per capita GDP (dollars) and nutritional energy supply (kilocalories per capita per day) based on data from 57 countries in 2001. The solid line shows the power-law regression (income elasticity 0.14, $R^2 = 0.71$), the shaded zone is the 90% confidence band.

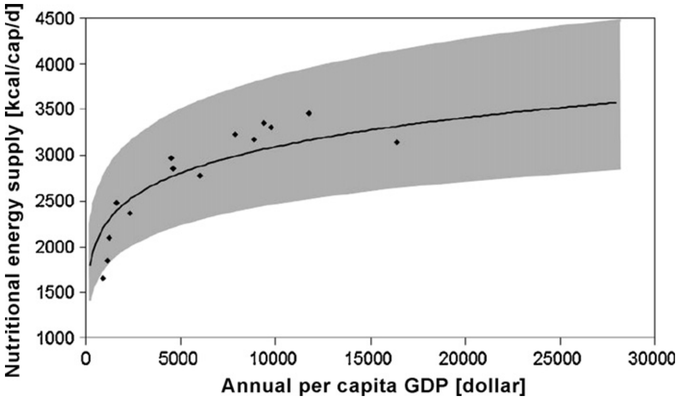

Fig. 3. Relationship between annual per capita GDP (dollars) and nutritional energy supply (kilocalories per capita per day) for France and Great Britain between 1700 and 2000 also showing the relationship of the cross-sectional analysis of Fig. 2. The solid line and shaded zone denote the relation identified in the cross-sectional analyses and the confidence band around it.

kilocalories per capita per day for low GDPs and 3800 kilocalories for high GDPs, a difference of a factor of almost two and a half. The figure also shows that for low GDPs increases in food supply per unit of GDP are large, while for high GDPs increases are much smaller and income does not seem to affect supply any longer.

The power-law relationship results in an R^2 of 0.71, the elasticity 0.14 inhibits a standard error of 0.013 (*t*-stat 11, *p* value 3.8×10^{-15}), while the logarithm of the constant is 2.93 with standard error 0.048 (*t*-stat 60.5, *p* value 3.7×10^{-49}). Data analysis suggests that income elasticity decreases with per capita income, but this does not result in a more significant relationship. The figure also shows an appreciable scatter around the identified relationship; the grey zone indicates the 90% confidence band. This scatter may be due to socio-economic factors, such as the share of income spendable on food, income distribution, or cultural differences in food consumption patterns.

Figure 3 shows that in France and Great Britain increasing per capita GDP parallels greater food supply, which doubles over the three centuries considered from 1700 kilocalories per capita per day in 1700–3500 kilocalories in 2000. The largest increase per unit of GDP occurs for incomes below 5000 dollars, while above this level the increase gradually slows down. The figure also shows the relationship identified in the cross-sectional analysis and the confidence band around it. Results for food supply in France and Great Britain are within the confidence band and qualitatively similar to trends in that analysis and show an income elasticity of 0.23: $E = 395\text{GDP}^{0.23}$. The R^2 is 0.88, the elasticity 0.23 inhibits a standard error of 0.024 (*t*-stat 9.6, *p* value 5.6×10^{-7}), while the logarithm of the constant is 2.6 with standard error 0.087 (*t*-stat 30, *p* value 1.3×10^{-12}). Quantitative differences may be due to, among other factors, limitations of the spatio-temporal analogue of comparing spatial differences between countries to temporal changes within countries.

Figure 4a–c depicts the results for southern Europe in the period 1961–2001. Figure 4a shows that nutritional energy supply increased from 2500 kilocalories per capita per day for a GDP of 3000 dollars (Portugal, 1961) to 3700 for a GDP of 12,500 dollars (Greece, 2001). Again, results are qualitatively consistent with the cross-sectional results (power-law relationship and confidence band); the income elasticity found here is 0.21. The relation reads $E = 475\text{GDP}^{0.21}$. The R^2 is 0.78, the elasticity 0.21 inhibits a standard error of 0.026 (t-stat 8, *p* value 2.6×10^{-7}), while the logarithm of the constant is 2.7 with standard error 0.10 (*t*-stat 26, *p* value 9.3×10^{-16}). Moreover, Fig. 4c shows that the fraction of food supply from animal sources is explained well by per capita income following a power-law with income elasticity of 0.43:

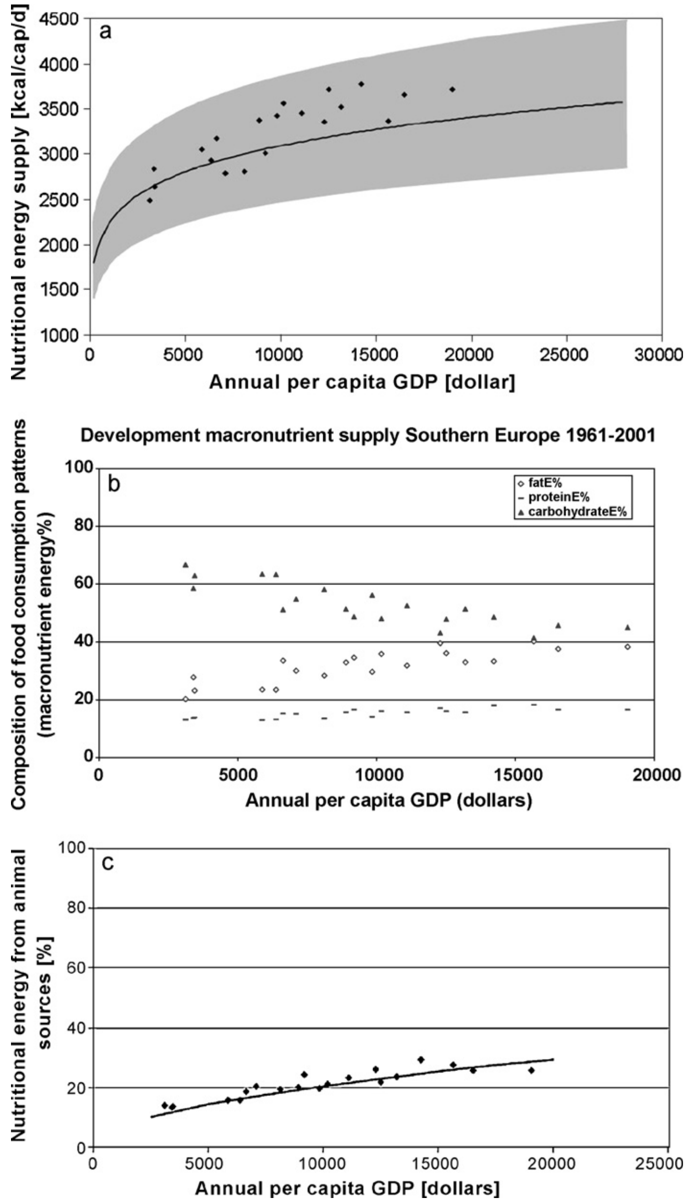

Fig. 4. (a) shows the relationship between annual per capita GDP (dollars) and nutritional energy supply (kilocalories per capita per day) for southern Europe between 1961 and 2001. The solid line and shaded zone denote the relationship identified in the cross-sectional analyses and the confidence band around it. (b) shows the relationship between annual per capita GDP and the composition of food consumption patterns in terms of the fraction of nutritional energy derived from fat (fat *E*%), protein (protein *E*%), and carbohydrate (carbohydrate *E*%) for southern Europe between 1961 and 2001. (c) shows the relationship between annual per capita GDP and the composition of food consumption patterns in terms of the fraction of nutritional energy from animal sources (%) for southern Europe between 1961 and 2001, and the relationship based on the cross-sectional analysis.

$A\% = 0.41 \times \text{GDP}^{0.43}$, R^2 is 0.88, the elasticity 0.43 inhibits a standard error of 0.037 (*t*-stat 11.5, *p* value 9.9×10^{-10}), while the logarithm of the constant is -0.39 with standard error 0.15 (*t*-stat -2.6, *p* value 0.016).

Per capita income and composition of food consumption

Figure 5a and b shows the relationship between the macronutrient composition of consumption and annual per capita GDP for the cross-sectional analysis. The fraction of nutritional energy provided by proteins does not change with income and is between 9 and 18 *E*%. The carbohydrate and fat *E*%, however, show a connection with GDP. It can be estimated from Fig. 5a that in

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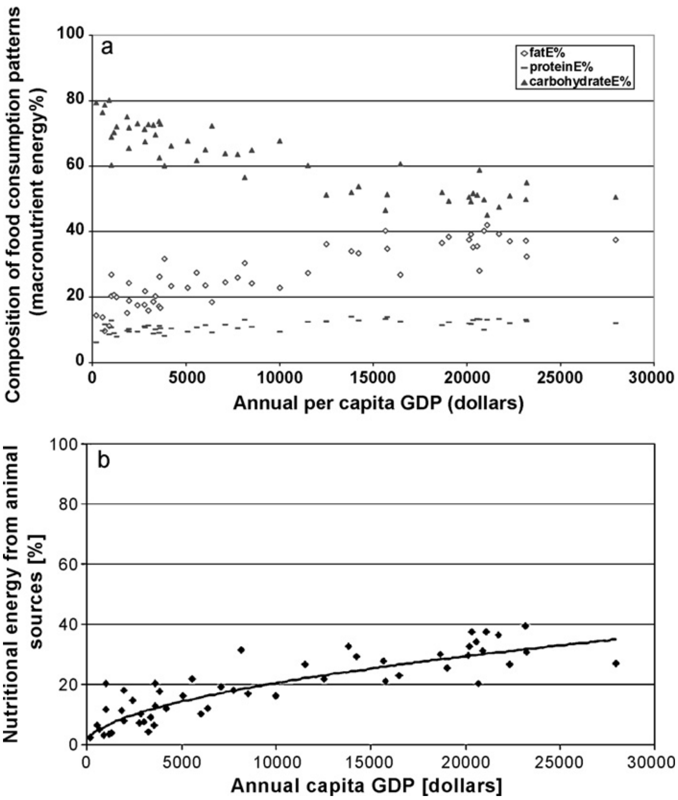

Fig. 5. (a) shows the relationship between annual per capita GDP and the composition of food consumption patterns in terms of the fraction of nutritional energy derived from fat (fat *E*%), protein (protein *E*%) and carbohydrate (carbohydrate *E*%). (b) shows the relationship between annual per capita GDP and the composition of food consumption patterns in terms of the fraction of nutritional energy from animal sources (*A*%); the solid line denotes the power-law function with income elasticity 0.52, $R^2 = 0.73$. The relationships were based on data from 57 countries in 2001.

countries with low GDPs, below 5000 dollars, people derive nutritional energy mainly from carbohydrates, with a small fraction from fats. In Bangladesh, for example, the country with the lowest GDP in the analysis, people derive 80% of nutritional energy from carbohydrates and 11% from fats. In consumption in countries with high GDPs, carbohydrates are less important and more energy is provided by fats. The average consumer in the US, France and Denmark, for instance, derives 45–50 *E*% from carbohydrates and 40 *E*% from fats. The figure also shows that for countries with low GDPs, small changes in income cause large changes in the composition of consumption, while for countries with high GDPs, small income changes do not affect composition because saturation has already occurred.

Although over the period 1961–2001 there were no average annual per capita GDPs of southern Europe countries below 3500 and above 19,000 dollars, when comparing Figs. 4b–5a, results show similar trends. Figs. 4c and 5b show the relationship between the fraction of nutritional energy derived from animal sources (*A*%) and GDP. For countries with low GDPs, *A*% is almost negligible; for countries with high GDPs, the fraction is about 25–40%. In Bangladesh, for example, *A*% is only 3%, while in Denmark *A*% is 40%. The figures show that for low GDPs, differences per unit of GDP are large; for high GDPs, differences per unit GDP are much smaller. It should be stressed, however, that *A*% indicates the fraction of energy derived from animal foods and not the amount consumed. Some countries with a high GDP, for example Canada and the US, show relatively small consumption of animal foods, 27 and 30 *E*% respectively. In absolute numbers, however, for the average Canadian the annual supply was 101 kg of meat and 204 kg of milk, while for a US citizen it was 121 kg of meat and 262 kg of milk. In an OECD country with a lower GDP than the US and Canada, the Netherlands, the relative consumption of animal foods is larger than in the US and Canada, 34 *E*%, but actual meat supply is less with 90 kg per capita per year and milk supply larger with 336 kg (FAO, 2010). The example also shows that consumption of animal foods does not increase indefinitely. Jobse-van Putten (1995), for instance, has also shown that in the western world high income groups consume less meat that low income groups. This trend has also been observed in Portugal (Rodrigues, Caraher, Trichopoulou, & De Almeida, 2008). Meat and milk require relatively large natural resource use (Wirsenius, 2003). Therefore this result is important from an environmental perspective.

In general, animal protein is of better quality than plant-based protein (Whitney & Rolfes, 1999). For most countries the protein *E*% does not show great differences. An increase in the fraction of nutritional energy derived from animal foods, therefore, does not imply an increase in the fraction of protein, but rather an improvement in protein quality. Especially for developing countries this trend is important, because it improves the quality of the consumption pattern.

Figure 5a and b also show that in some countries consumers deviate from trends. In Japan, for example, a high GDP is combined with a relatively small per capita food supply, while the composition of consumption also resembles a pattern related to a lower GDP. This indicates that factors other than GDP, such as culture, also affect consumption.

Figure 6 shows the fat *E*% of per capita consumption derived from 11 surveys in developing countries that make a distinction between urban and rural patterns. Apart from Egypt, urban consumption has a greater fat *E*% than rural consumption. The surveys were done in countries with relatively low GDPs, i.e. within the range where large differences in composition of food consumption occur per unit of GDP. It is likely that per capita GDP was higher for urban populations, which would explain the difference in fat *E*%. The result confirms the other trends.

Trends

Results of the cross-sectional and time series relationships all show that large changes in food supply and composition of consumption occur for relatively low annual per capita GDPs, below 5000 dollars, while for a GDP between 5000 and 12,5000 dollars changes are relatively small and above a GDP of 12,500 dollars food supply and the composition of consumption become quite stable. This is in accordance with many detailed studies of specific consumer groups, which have shown that increasing societal affluence causes shifts in the consumption of specific foods

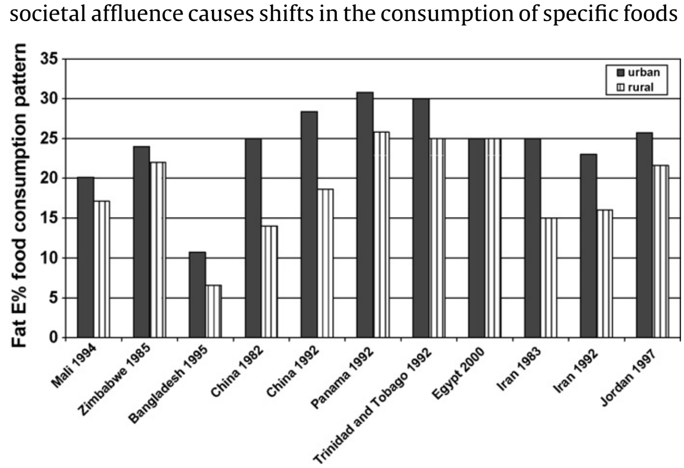

Fig. 6. Fraction of nutritional energy derived from fat (fat *E*%) for urban and rural populations in nine countries based on data from 11 food surveys in developing countries (see Appendix B).

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and commodities. It is also in accordance with Sen (1981) the Nobel prize winner who found that food shortages do not result from a lack of food but from a lack of access to food. By simplifying per capita consumption further than existing studies, we identify strong similar trends and shows general patterns in nutritional changes. When Figs. 2 and 5a are compared, an important result is that for low income countries the increase in supply happens faster than the change in composition. This is relevant for environmental studies. An increase in low incomes means initially that people buy more of the same foods. When this is the case the use of natural resources is linear to supply in terms of food calories. Next, people shift towards consuming more fats and animal foods and this change continues for longer. This requires the production of commodities that entail a different and possibly increased use of natural resources.

Per capita income and nutritional energy intake

Most of the available food surveys used in this study (see Appendix B) were done in countries with large differences in per capita income. Sixteen surveys indicate nutritional energy intakes between 2000 and 2500 kilocalories per capita per day, which is in the range of actual physical requirements (Whitney & Rolfes, 1999). Eight surveys show intakes between 1700 and 2000 kilocalories, while five studies report intakes of over 2500 kilocalories per capita per day. We find no relationship between nutritional energy intake and annual individual per capita GDP, however. For the Netherlands and the US, for example, two countries with a high GDP, energy intakes are between 2000 and 2500 kilocalories per capita per day. This is similar to intakes in countries with low GDPs. Twelve food surveys make a distinction between rural and urban consumption, but do not find substantial differences between energy intakes. The general impression is that in western countries per capita food consumption, expressed as nutritional energy intake, has increased over the last few decades. In science and anecdote it is often assumed that obesity is partly driven by eating specific foods or by eating in general (De Graaf, 2006; Mela, 2006; Van den Bos & De Ridder, 2006), while most people consider dieting to be a solution to the problem of obesity (Polivy & Herman, 2006). We show that nutritional energy intake is far more constant than food supply or the composition of consumption.

The gap between supply and consumption

Results show that when income increases the availability of food also increases (expressed as per capita supply in kilocalories), but actual consumption remains the same. This means that with increasing income, the size of the gap between actual per capita consumption and supply grows. For low GDPs the study finds a ratio of supply to actual consumption of about 1.0. For high GDPs, however, this ratio is higher, about 1.8, which indicates that about half of supply is not eaten at all. This gap is larger than estimates showing that in 1995 total losses in the food chain in the US were 27% of total supply (Scott Kantor, Lipton, Manchester, & Oliveira, 1997). That study, however, excludes weight reductions that occur when commodities are processed into final food products, so producing estimates lower than our results. A possible explanation is that affluent countries with a high GDP also have more industrialized food industries with longer food chains that are probably less efficient, than countries with low GDPs. Another explanation might be that in countries with a low GDP, where food is more scarce, people prepare and consume food more efficiently and so generate fewer and smaller waste streams. The FAO food balance sheets do not provide information to confirm this hypothesis. The evaluation of the increasing gap between supply and per capita consumption that coincides with increasing GDP requires further research. The result is important for environmental sciences, because it means that rising incomes are accompanied by a less efficient use of natural resources.

Uncertainty and inaccuracy of results

Four factors cause uncertainty and inaccuracy of results. These are: (i) data quality; (ii) the use of average data; (iii) the use of supply data and (iv) the use of inhomogeneous data. A fifth factor adds to uncertainty in interpreting the results: (v) uncertainty in spatio-temporal analogues.

Data quality

The first factor that contributes to uncertainty and inaccuracy is data quality. This study derives data on food supply from FAO food balance sheets (FAO, 2010), for which the FAO obtains data from national datasets. However, data from different countries probably are not of equal quality, as this depends on the degree of development of national statistical organizations. Within countries, data quality varies between years. Major events, such as political instability, or improvements in the methods of statistical organizations affect data quality. Even in countries with high-standard statistical organizations, different sources provide different data. For the Netherlands in 2000, for example, per capita butter consumption varies by a factor of three among datasets. According to the FAO the Dutch consume 2.1 kg of butter per capita per year (FAO, 2010), according to the Statistics Netherlands (CBS) 3.3 kg (LEI-DLO/CBS, 2002) and Eurostat estimates 6.8 kg (LEI-DLO/CBS, 2002). The FAO adjusts basic data and estimation/imputation of the missing data is necessary in order to maintain a certain degree of consistency, completeness and reliability in the food balance sheets (FAO Statistics Division, 2008). Although for some countries data quality might be poor, the FAO food balance sheets are the only source of information available to perform an analysis of the type presented here.

The study derives data on GDP from Maddison (2003), who has expressed GDP in 1990 International Geary-Khamis dollars. The Geary-Khamis system is an aggregation method in which international prices and a country's Purchasing Power Parity, depicting relative country price levels, are estimated from a system of linear equations and expressed in G-K dollars (United Nations Statistics Division, 2006). Individual country GDP values can be substantially different depending on the PPP methodology used, however. To compare cross-sectional and time series relationships this study prefers to apply only one source of GDP data and therefore uses the database of Maddison (2003), since it covers both historical and recent global information.

Data on historical food supply are obtained from the historical analysis of Fogel and Helmchen (2002). That study reported nutritional energy intakes below physiological requirements. In general, nutritional energy requirements are constant per unit of body mass (Whitney & Rolfes, 1999). Average energy intakes below the physiological requirement might be possible, though, if the fact that three centuries ago people were smaller and had more children, with less body mass, is taken into account.

The use of average data

The second factor that contributes to uncertainty and inaccuracy is the use of average data. Per capita data are derived from information on a national level and are therefore average numbers. In some countries, disparity in income distribution is large and differences in food consumption occur among population groups. These differences are not reflected in national data, which means that the use of average data underestimates trends found here.

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The use of supply data

The third factor that contributes to uncertainty and inaccuracy is the use of FAO supply data that exclude non-market production. Sometimes people produce food outside the market, for example in their gardens (Fernandes & Nair, 1986; Pallot & Nefedova, 2003). The FAO food balance sheets give supply data on a national level and do not take non-market production into account (FAO, 2010). By thus excluding non-market production, we probably underestimate supply.

The composition of supply and consumption

Before food is available for consumption, commodities and foods go through complete food chains, from farm to fork, in which processes are used to produce the final foods. In all chain links and in transportation between links losses occur. Neglecting losses and excluding non-market production could have an effect on the assessments. To analyze the use of supply rather than consumption data in the analysis of trends in the composition of national food supply, this study compares differences between the composition of per capita consumption and related supply. Every commodity has a specific composition in terms of macronutrients, such as the fat *E*%. Results have already shown that the contribution of protein to nutritional energy of consumption, the protein *E*%, is stable, but that fat and carbohydrate *E*% vary, reflecting a difference in the composition of consumption. We assume that a difference in fat *E*% between per capita consumption and related supply reflects a difference in composition. For the comparison the study uses information on the fat *E*% obtained from 18 food surveys, marked with an asterisk (*) in Appendix B. The study calculates the fat *E*% of related supply using Eq. (2), deriving data from the FAO (2010).

Figure 7 shows that the fat *E*% of consumption and related supply are similar, indicating that the macronutrient compositions are the same. Eventual losses or non-market production do not cause shifts in the composition. This justifies the use of FAO data for the analysis of trends in the composition of national food supply.

The use of food survey data

The fourth factor for uncertainty and inaccuracy is that the study derives information from food surveys that were probably all performed in different ways, generating different types of inaccuracies and uncertainties. For example, people tend to underreport consumption (CBS, 1994; Kok et al., 1993). The way food surveys have addressed this problem has probably varied among surveys, causing diverse inaccuracies. The lowest value is for the Philippines at 1800 kilocalories per capita per day and the highest for Jordan, 3200 kilocalories per capita per day. These examples show that methods used for surveys have probably differed, generating under- and overestimations, an unquantified inhomogeneity that the present analysis cannot compensate for.

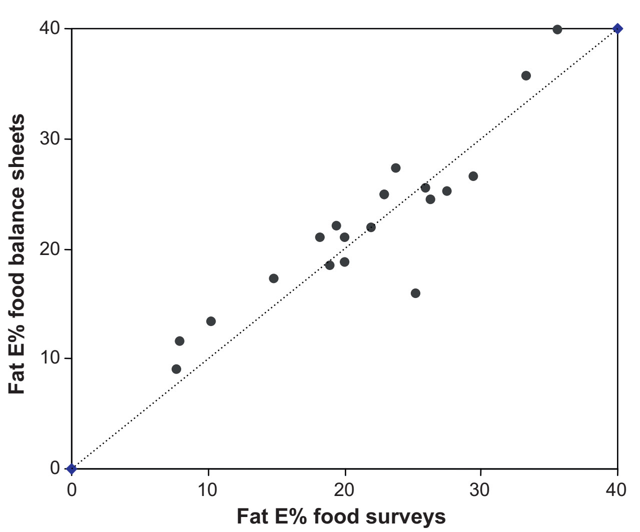

Fig. 7. Comparison between the fraction of nutritional energy derived from fat (fat *E*%) of actual consumption and of related supply. Data on fat *E*% of consumption were derived from food surveys, the fat *E*% of related supply was calculated from FAO food balance sheets.

The use of spatio-temporal analogues

An additional fifth factor of uncertainty in interpreting the results concerns the use of results from cross-sectional analyses for drawing temporal inferences. Interrelations between countries and globalization impact on developments in the economy, agricultural technology and cultural preferences in, especially, developing countries in a way that may significantly deviate from historical and present trends in developed countries. Illustrations of this are the quantitative differences between the cross-sectional results and the results from the long and medium-term longitudinal analyses of European countries. Deviations found, however, are restricted to quantitative results, qualitative findings were found to be robust. Projections based on the identified relations are therefore quantitatively uncertain.

Future changes

Although there are many uncertainties and despite the use of rough estimates, differences among countries, developments in time and differences between urban and rural populations, all results show similar changes in direction. It is stressed, however, that results obtained here cannot be taken at face value. They give an indication of the direction of changes in food supply, the composition of consumption and the contribution of animal foods and of their magnitude. Combined with estimates of increases in GDP, the study provides a tool to quantify these changes and indicate where and when they will probably take place.

The most important finding of this paper is that the main changes occur for per capita annual incomes below 12,500 dollars. If trends found here are also valid for the future, this has important consequences in the coming decade not only for food security, but also for the use of natural resources such as arable land and freshwater. Currently, about 85% of the world population lives in six regions: (i) the OECD countries, (ii) Latin America, (iii) Africa, (iv) China, (v) India and (vi) the rest of Asia. Table 1 shows the nutrition, GDP and population characteristics of these regions.

In four regions per capita income levels are below 5000 dollars per year, i.e. within the range where the largest changes occur. China, India and the rest of Asia combine low GDPs with large growth rates. This means that in the next 10 years considerable changes are likely to occur in Asia. If the Asian countries maintain economic growth along existing lines, the next decade might show a substantial increase in per capita food supply, while the composition of consumption might shift towards the affluent patterns of western countries, characterized by substantial consumption of fats and animal foods and limited consumption of starchy staples. Latin America and Africa will probably see little economic growth. There, population growth will be the main driver in increasing total food demand. For the OECD no substantial changes are likely, because food consumption in these countries has already reached saturation level and population size is more or less stable.

To estimate food demand for the period 2003–2030, the FAO (2003) has indicated that developing regions will show a shift

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Table 1
Per capita nutrition characteristics in 2001, GDP characteristics (dollars), expected national GDP growth and population characteristics for six regions (85% of the global population).

Region	Nutrition characteristics 2001[a]				GDP characteristics[b]			Population characteristics		
	Energy supply[c]	Fat E%	Protein E%	Energy from animal sources (%)	Annual per capita GDP 2001	National GDP growth[d]	Estimated annual per capita GDP 2015	Size 2001 (billion)[e]	Annual growth[f]	Size 2015 (billion)
China	2953	26	11	20	3800	8%	11,600	1.29	0.7%	1.42
India	2385	19	9	8	1926	6%	4,300	1.03	1.4%	1.25
OECD	3493	36	12	27	21538	2%	29,500	0.89	0.4%	0.94
Asia[g]	2540	18	9	9	2760	7%	7,000	0.76	1.3%	1.20
Africa	2519	18	10	7	1615	4%	2,900	0.52	2.6%	0.74
Latin America	2905	26	11	20	6174	2%	8,400	0.45	1.3%	0.54

[a] *Source*: FAO (2010).
[b] *Source*: Maddison (2003).
[c] Kilocalories per capita per day.
[d] Based on data from the International Monetary Fund, 2010IMF (2010) for 2001–2005.
[e] *Source*: FAO (2005).
[f] *Source*: FAO (2003).
[g] Without China and India.

towards increased food supply, as well as greater consumption of specific commodities such as cereals, sugar, oils and animal foods, while consumption of pulses, roots and tubers will decrease. When information from our study is combined with estimates of GDP growth, results can contribute to the scenario analysis of the FAO and provide additional information on when and where changes are likely to occur.

The impact on natural resources

Increased supply or a shift in consumption towards foods with greater requirements for natural resources will have impacts on the production system and the pressure on these natural resources. The European transition towards affluent food consumption patterns was a gradual process, taking place over centuries. The economies developed step by step and agriculture could keep pace with the growth in demand. Today, economic growth occurs at a much faster rate (Maddison, 2003). Especially for developing countries with a low GDP, this process contributes to pressure on agriculture to produce sufficient food of a required quality in the coming decade.

At present 38% of the global land area is in use for food production (FAO, 2003) and sustainable options to increase this are few. Moreover, in the last 10 years a global deceleration of yield growth occurred (FAO, 2003). The pressure on freshwater is also great. Humans already use 86% of freshwater, mainly for agriculture. This water can for a large part be attributed to the consumption of animal foods (Hoekstra & Chapagain, 2007). The expected global increase in consumption of these foods, therefore, will put additional pressure on the availability of freshwater. While land and freshwater are mainly needed in agriculture, energy requirements occur in all links of a food chain. In the past decades energy requirements for food increased not only due to consumption of different foods, but also due to the use of other production and transportation methods (Gerbens-Leenes, 2006). It can therefore be expected that the general trends of consumption found in this study will also have a considerable impact on energy use. Knowledge of the impact of different food items and categories on the use of resources provides a tool to indicate pathways towards more sustainable consumption, for example by increased efficiency, prevention or substitution.

Conclusions

The study confirms that throughout the world a nutrition transition is taking place, in which people shift towards more affluent food consumption patterns. This transition is taking place at different stages and at different paces. The cross-sectional and time series relationships show similar patterns of change. For low income countries, an increase in per capita GDP is accompanied by changes towards the food consumption patterns of western countries, characterized by a large gap between supply and actual consumption. Whereas actual consumption remains stable, total supply (kilocalories per capita per day) differs by a factor of two between low and high income countries. In this way economic growth also causes a shift towards a more inefficient food system, with greater use of natural resources. A second characteristic of changes in consumption is the switch in the fraction of nutritional energy from carbohydrates to fats and to animal foods, while the protein fraction remains stable. People with low incomes derive nutritional energy mainly from carbohydrates; the contribution of fats to nutritional energy is small, that of protein the same as for high incomes and that of animal sources negligible. People with high incomes derive nutritional energy mainly from carbohydrates and fats and the contribution of animal sources is substantial. In general, whenever and wherever economic growth occurs, per capita food supply and the composition of supply and consumption show the same change of direction. The results of the study are based on a simplified food system using rough estimates. In reality, the food system is far more complex and there are many factors, such as culture, that influence food consumption patterns. By simplifying the system, the study shows general trends that would not have been found in a more detailed analysis. For specific situations, however, results might deviate from trends found in here.

The importance for environmental studies is that results show that the largest changes in food consumption patterns, and thus the largest increase in the use of natural resources, occurs in the range of incomes below 5000 dollars per year, i.e. in developing countries. With an income of above 12,500 dollars saturation has occurred and per capita use of natural resources for food does not necessarily increase any further. In the coming 10 years large changes in food consumption patterns are likely to occur in Asia and especially in China and India, two countries that combine great economic growth, low income levels and poor food consumption patterns. The European transition occurred gradually, enabling agriculture and trade to keep pace with the growth in demand. Changes in economic circumstances change the demand for food. A continuation of present economic trends might cause a considerable pressure on the food system, because changes are occurring much faster than they did in Europe and causing additional pressure on finite natural resources.

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Appendix A

Overview of the 57 countries for which this study performed the cross-sectional analysis.

Africa: Algeria, the Democratic Republic of Congo, Côte d' Ivoire, Egypt, Ethiopia, Ghana, Kenya, Morocco, Nigeria, Sudan, Tanzania, and South Africa

Asia: Bangladesh, China, India, Indonesia, Malaysia, Pakistan, the Philippines, Sri Lanka, Thailand, and Vietnam

Eastern Europe: Poland

Latin America: Argentina, Brazil, Chile, Colombia, Ecuador, Guatemala, Mexico, Peru, and Venezuela

Middle East: Israel, and Syria

OECD: Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, the Netherlands, Portugal, Spain, Sweden, Turkey, United Kingdom, United States

Additional, small countries: The United Arab Emirates, Estonia, Slovenia.

Appendix B

Overview of countries and national food surveys used in this study. The 18 food surveys that provide data on fat *E*% are marked with an asterisk *.

Argentina

Britos, S., & Scacchia, S. (1998). *Disponibilidad y consumo de alimentos en Argentina. Escuela de Nutrición* [*Food availability and consumption in Argentina. School of Nutrition*]. Argentina: Universidad Nacional de Buenos Aires [National University of Buenos Aires].

*Bangladesh**

Jahan, & Hossein. (1998). *Malnutrition in Bangladesh: Bangladesh National Nutrition Survey, 1995–96*. Bangladesh: Institute of Nutrition and Food Science, Dhaka University.

Brazil

Galeazzi, M. A. M., & Falchoni Jr., P. (1998). *Inquérito de Consumo Alimentar da Area Metropolitana de Brasîla-Relatório* [*Nutrition survey in the area of Brasilia-Relatorio*]. Brasília: Técnico-Secretaria de Saúde de Brasília.

Cambodja

National Institute of Statistics (NIS/MOP). (1996). *Socio-Economic Survey of Cambodja. Data from the Multi-Indicator Cluster Survey (MICS) of the Socio-Economic Survey of Cambodja (SESC) sponsored by the Asian Development Bank in collaboration with the UNICEF/UNDP/CARERE and ILO*. Cambodja: Royal Government of Cambodja.

*China**

Ge, K., Zhai, F., & Yan, H. (1996). Institute of Nutrition and Food Hygiene (INFH) 1985. *Summary Report of the 2nd National Nutrition Survey in 1982*. Beijing, China: Institute of Nutrition and Food Hygiene.

Ge, K., Zhai, F., & Yan, H. (1996). The dietary and nutritional status of Chinese population. 3rd National Nutrition Survey, 1992. Beijing, China: People's Med. Pub. House.

Colombia

Ministerio de Agricultura DANE-DRI-PAN. (1984). *Encuesta Nacional de Alimentatión, Nutrición y Vivienda DANE-PAN-DRI 1981* [Ministry of Agriculture DANE-DRI-PAN 1984. National Feeding, Nutrition and Housing Survey *DANE-PAN-DRI 1981]*. Bogotá: Franza Pardo T-Bogotá (Mimeógrafo).

Costa Rica

Ministerio de Salud. (1996). Ministerio de Salud 1996. *Encuesta Nacional de Nutrición. Fasciculo N^o 1: Consumo Aparente* [Ministry of Health 1996. *National Nutrition Survey. Fascicle N^o 1: Apparent Consumption*]. San José, Costa Rica.

*Egypt**

Hassanyn, A. S. (2000). *Food Consumption Pattern and Nutrients Intake Among Different Population Groups in Egypt*. Final Report (Part 1). Egypt: Nutrition Institute, WHO/EMRO.

El Salvador

Asociación Demográfica Salvadorẽna (ADS), Ministerio de Salud Pública y Asistencia Social (MSPAS), & Instituto de Nutrición de Centro América y Panamá (INCAP) [Salvadoran Demographic Association, Ministry of Public Health and Social Assistance, & Institute of Nutrition of Central America and Panama (INCAP)]. (1990). *Evaluación de la Situación Alimentaria Nutricional en El Salvador* [*Evaluation of the nutritional situation in El Salvador*]. El Salvador: ESA NES-88.

Equador

Freire, W. (1988). *Diagnóstico de la situación alimentaria y nutricional y de salud de la población ecuatoriana menor de cinco años – DANS -1986* [*Diagnosis of the alimentary, nutritional and health state of the Ecuadorian population less than five years – DANS -1986*]. Quito, Equador: CONADE, MSP.

*Iran**

Djazayery, A., & Samimi, B. (1996). (Surveys for 1983 and 1992) Food consumption and energy intake patterns in the rural and urban areas of Iran, 1983–1992. *Agricultural Economics and Development, 4*, 218–248.

Jamaica

Simeon, D. T., & Patterson, A. W. (1994). *Energy and protein accessibility at the household level in Jamaica: Results from a national survey 1989*. Jamaica: CFNI.

*Jordan**

Department of Statistics (DOS). (1997). *Household Income and Expenditure Survey*. Amman, Jordan.

Madagaskar

FAO. (2004). *L'état de l'insécurité alimentaire 2001 dans le monde* [*The state of food insecurity in the world*]. Rome, Italy: Organisation des Nations Unies pour l'alimentation et l'agriculture [Food and Agriculture Organisation of the United Nations], http://www.fao.org.

*Mali**

FAO. (2005). *Profiles nutritionnels par pays* [*Nutritional profiles per country*]. Mali: Departement Economique et Social, Alimentation et nutrition [Department of Economic and social affairs, food and nutrition]. http://www.fao.org/es/nutrition/mli-f.stm.

*Mexico**

INNSZ. (1990). *Encuesta Nacional de Alimentación en el Medio Rural ENAL 1989* [*National Feeding Survey in Rural Areas ENAL 1989*]. México: INCMNSZ.

Avila, A., Shamah, T., & Chavez, A. (1997). *Enquestas de Alimentación y Nutrición en el Medio Rural, 1996. Resultados por entidad* [Feeding and Nutrition Surveys in Rural Areas, 1996. *Results by organization*]. *INNSZ, DEDESOL, DIF, SSA, Golernos de los Estados* [*Governments of the States*]. Mexico: IMSS, INI, Unicef.

*The Netherlands**

Voedingscentrum [Food Center], & TNO. (1998). *Zo eet Nederland 1998* [*This is how the Netherlands eats 1998*]. Den Haag, the Netherlands: Voedingscentrum [Food Center].

Panama

Ministerio de Salud. (1992). Ministerio de Salud 1992. *Encuesta Nacional de Consumo de Alimentos*. Panamá: Departamento de Nutrición y Dietética Panamá [Ministry of Health 1992. *National Food Consumption Survey*. Panamá: Dietetic and Nutrition Department Panamá].

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Peru

Amat, C., & Curonisy, P. (1981). *La alimentación en el Perú* [*Feeding in Peru*]. Lima, Perú: Centro de Investigación [Research Center University of the Pacific].

*Philippines**

Food and Nutrition Research Institute of the Department of Science and Technology (FNRI-DOST) of the Philippines. (2000). *National Survey of 1993: Final Results*.

*Sri Lanka**

Department of Census and Statistics. (1993). *Household Income and Expenditure Survey 1990/91, Final Report. Department of Census and Statistics*. Sri Lanka: Ministry of Policy Planning and Implementation.

*Turkey**

Hundd, & Moh. (1997). *Food consumption survey in 7 provinces, Project Report*. Ankara, Turkey: Hacettepe University, Department of Nutrition and Dietetics, Ministry of Health.

*United States**

United States Department of Agriculture (USDA) Agricultural Research Service. (2005). Food and Nutrient Database for Dietary Studies, 1.0. http://www.ars.usda.gov/Services/docs.htm?docid=7637.

*Venezuela**

Luna Bazó, P., & Bracho, M. (1987). *Encuesta Nacional de Nutrición. Area Socio Alimentaria "Encuesta de Consumo". Mimeografiado* [*National Nutrition Survey. Socio Alimentary Field "Consumption Survey". Mimeografiado*]. Caracas, Venezuela: Instituto Nacional de Nutrición, Direccion Téchnica [National Nutrition Institute, Technical Direction].

*Vietnam**

Tu Giay, & Chu Quoc Lap. (1990). *Final report on the subject 64D.01.01 of the National Research Programme National General Survey 1989.* Hanoi, Vietnam: The Governmental Science and Technology Committee, NIN.

National Institute of Nutrition (NIN). (1995). *Sentinel food and nutrition surveillance system data*. Hanoi, Vietnam: NIN.

Zimbabwe

Bursztijn, P. G. (1985). A diet survey in Zimbabwe. *Human Nutr. Appl. Nutr. 39* (5), 376–388.

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FAO. (2010). Food Balance Sheets. http://www.fao.org

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