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SUSTAINABLE CONSUMPTION: SECTOR CASE STUDY SERIES

HOUSEHOLD FOOD CONSUMPTION: TRENDS, ENVIRONMENTAL IMPACTS AND POLICY RESPONSES

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FOREWORD

The Sector Case Study on Household Food Consumption

This document is the Report of the sector case study on Household Food Consumption conducted as part of the sector case studies series of the OECD Environment Directorate's 1999-2000 Programme on Sustainable Consumption. The Report traces household food consumption patterns and related environmental impacts in four OECD countries: Austria, Poland, Sweden and the United States. It looks at the economic, demographic, social and cultural factors driving food consumption patterns, and policy options for reducing environmental impacts. This Report also includes the results of a separate study on *Methodologies for Evaluating the Environmental Impacts of Household Food Consumption Patterns* exploring how well we can measure the environmental impacts of household food choices and which methodologies and indicators are currently the most useful.

The OECD Secretariat expresses it thanks and appreciation to the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management, the Polish Ministry of Economy, Ministry of Environment and Ministry of Agriculture and Rural Economy, and the Swedish Environmental Protection Agency for sponsoring their country studies, and to national case authors Harald Payer, Petra Burger and Sylvia Lorek (Austria), Dr. Wlodzimierz Sekula (Poland), Ingrid Jedvall (Sweden), Dr. Joanne Kauffman and Frédérique Chevrot (US), and to Dr. Niels Jungbluth and Dr. Rolf Frischknecht (ESU-Services) for their work on methodologies and indicators. This Report has been prepared by Elaine Geyer-Allély. It is published under the responsibility of the Secretary-General of the OECD.

The OECD Programme on Sustainable Consumption

The OECD 1999-2000 Work Programme on Sustainable Consumption provides new data and analysis to help OECD member countries reduce the environmental impacts from household consumption patterns. The Programme combines empirical studies of consumption trends in OECD Member countries with conceptual and policy analysis. Programme elements include: development of a conceptual framework to set out boundaries of analysis and policy to influence household decisions; sector case studies documenting trends, environmental impacts, and policy options in three key areas of household decision-making; policy case studies to deepen analysis of policy instruments that influence household consumption of final goods and services; and refinement of a body of indicators to assess progress towards more sustainable consumption patterns. The results of these 8 elements of work are published separately and drawn together in a Synthesis Report (see below). For more information contact the OECD Environment Directorate: www.oecd.org/env.

OECD Environment Directorate 1999-2000 Programme on Sustainable Consumption **REPORTS**	
Promoting Sustainable Consumption in OECD Countries: Household Consumption Trends and Policies. ***Synthesis Report of the 1999-2000 Programme on Sustainable Consumption***	**ENV/EPOC/WPNEP(2001)19**
Conceptual Analysis *Towards Sustainable Consumption: An Economic Conceptual Framework*	**ENV/EPOC/WPNEP(2001)12**
Sector Case Studies *Household Food Consumption: Trends, Environmental Impacts and Policy Responses* *Household Tourism Travel: Trends, Environmental Impacts and Policy Responses* *Household Energy and Water Consumption and Waste Generation: Trends, Environmental Impacts and Policy Responses*	 **ENV/EPOC/WPNEP(2001)13** **ENV/EPOC/WPNEP(2001)14** **ENV/EPOC/WPNEP(2001)15**
Policy Case Studies *Information and Consumer Decision-Making for Sustainable Consumption* *Participatory Decision Making for Sustainable Consumption* *Policies to Promote Sustainable Consumption: An Overview*	 **ENV/EPOC/WPNEP(2001)16** **ENV/EPOC/WPNEP(2001)17** **ENV/EPOC/WPNEP(2001)18**
Indicators *Sustainable Consumption Indicators*	 **Forthcoming 2002**

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EXECUTIVE SUMMARY

Consumer demand for different food products has changed in important ways in OECD countries over the last thirty years driven by increasing per capita incomes, demographic shifts, and lifestyle changes. At the same time there have been significant structural changes in the food production and processing sectors. These changes have been driven by consumer demands but also by concentration and competition in the international food market, farm policy and programmes, technological innovations, and public policy and private attitudes related to food safety, nutritional labelling, environmental concerns and other food-related issues.

These changes in food production and consumption patterns in OECD countries have important implications for the environment. Although the most significant environmental impacts arise high in the food production and processing sectors, OECD households influence trends in these areas through their choice of diet and their demand for food-related services. Households also have direct environmental impacts through the way they purchase, store and prepare their food, and how much organic and packaging waste they generate. The OECD Sector Case Study on Household Food Consumption explored these impacts through case studies in four OECD countries: Austria, Poland, Sweden and the United States. This Report presents the key results from the national case studies and a separate study on methodologies and indicators for estimating household environmental impact.

Despite sometimes significant differences in per capita consumption of major food categories OECD countries share a rising trend toward higher consumption of meat (except Poland), cheese, fruits, vegetables and bottled drinks. Total caloric content is also increasing in several countries despite an already high calorie intake. Consumer spending on food as a percentage of total household expenditure has steadily declined in most countries, sharpening competition in the food processing and retail sectors and leading to an explosion in the number of food products and services offered to the consumer. Changes in the structure of the food production, processing and retail sectors reflect these trends. The Report draws on the Needs-Opportunities-Abilities model of consumer decision-making to identify the major motivations behind observed household food consumption trends:

The Needs-Opportunities-Abilities and household food consumption		
Technology (food production, preparation and conservation), **Policy** (regulations, information) **Demographics** (household size, employment), **Culture** (Gender, religion, age)		
NEEDS	**OPPORTUNITIES**	**ABILITIES**
Nutrition and Health	Food prices	Per capita disposable income
Convenience	Food products and services available	Education and Information: Nutrition, Exposure to food and food preparation skills, Environmental awareness
Variety	Advertising	

The environmental impacts of household food consumption patterns depend on several factors, including where and how food is produced, processed, packaged, preserved, distributed, prepared and disposed of. The Report documents direct household impacts from household food consumption patterns in the areas of energy consumption, waste generation, transportation and GHG emissions. For example:

- *Energy*: The use of energy for food-related activities constitutes an important, but not the dominant, component of total household energy use (7-12%) although household *electricity* consumption has continued to grow with GDP due largely to expanding household ownership of appliances, including food related appliances (refrigerators, freezers, dishwashers, microwaves). There is still significant potential for efficiency gains for many household appliances and in food preparation techniques.
- *Transport*: The direct food-related transport impacts from household food consumption patterns are mainly related to individual passenger-car traffic, but the net impact of changes in food shopping patterns and the rapid increase in the number of hypermarkets and food shops, often located outside large cities and small towns, has not been fully evaluated. In the US, for example, shopping distances appear to be declining although the data are not disaggregated by shopping purposes. On the other hand, anecdotal information in Poland linked to a 15-fold increase in car ownership over the last 30 years (33-fold in the largest cities) and the creation of out-of-town hypermarkets suggests a growing portion of transport miles for household food shopping. Transport impacts are also tied to consumer demand for variety and year-round availability of certain food items.
- *Food and packaging waste*: Food losses begin on the farm and continue through the retail chain to the consumer. In the US, according to a study carried out by the USDA Economic Research Service more than 43.6 billion kilograms (27% of edible food available for human consumption in 1995) were lost by retailers, the food service industry and consumers. Food service and consumer food loss accounted for nearly all of the waste. Food waste is the wettest and most dense component of domestic waste streams; composting is underdeveloped. The trend toward increased packaging for household goods, including pre-packaged foods and food service packaging has helped reduce food waste from spoilage, transportation and storage. However, it has also significantly increased the amount of non-organic wastes entering the waste stream from household food consumption and diversified the materials. Although recycling rates for many packaging materials have increased, wastes from household food consumption are among the least affected by these trends.
- *Greenhouse gas emissions*: Household GHG emissions are related to direct energy consumption for food conservation and preparation, food transport patterns, and choice of diet through upstream impacts on production, processing and distribution patterns. According to one German study the distribution and consumption of food together account for 42% of all CO_2 emissions connected to the food sector. Recent work using Lifecycle Analysis (LCA) provides additional information on the choice of diets and related impacts on global warming, and shows the importance of considering both production processes and transport distances when considering the GHG impact of one food product over another.

The most significant food-related environmental impacts are high in the production chain and have been studied and well documented elsewhere in the OECD. The Report provides a subset of examples to underline the link between changes in household demand for certain food products and services and environmental impacts higher in the food system. The demand for year-round availability of fresh fruits and vegetables, for example, has an impact through energy demand for greenhouse production or long-distance transport by road or air. The growing demand for lean meat has led to intensive animal production systems for pig meat and poultry that are important sources of water pollution. The Report also briefly highlights some of the principal environmental pressures stemming from the food processing, distribution and retail sectors, which have received less attention to date in the OECD. Key environmental aspects related to these sectors include energy use, GHG emissions, discharge of high-strength effluents,

localised odour problems, air pollution and chemical use and storage. From a policy perspective, this discussion is important for determining the most effective points for technological innovations or policy measures to reduce environmental impacts if short- to medium-term household food consumption patterns are taken as given.

The quantification of environmental impacts from household food consumption is a relatively undeveloped area of public policy research. In many cases, data are hard to find, or are collected at an aggregate level that makes it difficult to link household behaviour with a specific level of impact, and thus to define appropriate policy instruments. The information available from the case studies varies considerably in depth of analysis and data availability. Several methodologies have been developed and applied to food consumption analysis that can help improve the assessment of environmental impacts. The Report reviews some of those methodologies and proposes a set of 14 indicators that could be used to more closely monitor environmental impact trends in this area.

The Report concludes with a discussion of policy objectives and framework for policies to promote sustainable household food consumption. It shows that although there are no "sustainable food consumption" policies, growing concern over environmental health and food security are forging stronger links between traditional nutrition and consumer safety policy and environmental policy. It also examines specific policy measures to reduce the direct environmental impacts from household food consumption patterns. The discussion shows that some policies exist to deal with general household energy consumption and waste generation patterns (i.a. regulatory and voluntary efficiency standards, user charges, and labelling and information initiatives), including sometimes specific measures relevant to household food activities (food and packaging waste). On the other hand, there are few examples of policies to deal specifically with food transportation or the greenhouse gas effects of food consumption patterns. The discussion also makes clear that household food consumption patterns should not be treated in isolation but rather addressed as an important part of a set of daily household routines that influence and reinforce one another. More systematic analysis of the environmental and cost effectiveness of policy instruments to reduce the environmental impacts of food consumption is needed to refine this discussion. The Report also discusses policies and information to support informed consumer choice as one way of influencing upstream impacts in the food production and processing sectors and identifies issues where additional research is needed to better understand the net environmental impact of evolving food consumption trends.

1. INTRODUCTION

Consumer demand for different food products has changed in important ways over the last thirty years in OECD countries. Household consumers increasingly want a food supply rich in convenience and variety. Increasing per capita incomes, demographic shifts, and lifestyle changes have increased the demand for processed and imported food and individual portions and packaging. More meals are prepared outside of the home. Consumers are also more aware of nutritional and safety issues that are now fueling fast-growing niche markets for organic and so-called "functional" foods.

At the same time there have been significant structural changes in the food production and processing sectors. These changes have been driven by consumer demands but also by concentration and competition in the international food market, farm policy and programmes, technological innovations, and public policy and private attitudes related to food safety, nutritional labelling, environmental concerns and other food-related issues. The agro-food sector has evolved significantly over the last three decades in a continual search for innovative ways to produce, market, process and deliver food and to capture consumer markets.

These changes in food production and consumption patterns in OECD countries have important implications for the environment. Although the most significant environmental impacts arise high in the production and processing sectors, OECD households influence trends in these areas through their choice of diet and their demand for food-related services. Households also have direct environmental impacts through the way they purchase, store and prepare their food, and how much organic and packaging waste they generate.

The OECD Sector Case Study on Household Food Consumption explored these impacts in case studies of four OECD countries: Austria, Poland, Sweden and the United States. In each country, case study teams followed a common terms of reference to explore trends in household food demand, the economic, demographic and social factors driving these trends, and their environmental impacts. Finally, the case studies also briefly explored the policy implications of household food consumption patterns. A separate study was also commissioned on methodologies and indicators for estimating the environmental impacts from household food consumption patterns.

This Report presents the key results from the national case studies and the separate study on methodologies and indicators for estimating household environmental impact. The Report is organised as follows:

Section II describes trends in the household demand for major food groups and food services (shopping, out-of-home food preparation). This section also describes some of the key forces driving household food consumption patterns, including, for example, increasing incomes, shrinking time budgets, waning interest in food preparation, and a burgeoning taste for variety. This section also highlights, but does not discuss in depth, changes in the structure of the food processing and distribution and retail sectors that have a direct or indirect influence on household food consumption patterns.

Section III describes direct environmental impacts from consumer food choices at the household level in the areas of energy, transport, food and packaging waste, and greenhouse gas (GHG) emissions. This section also briefly reviews some environmental impacts in the food processing and distribution

sectors that are influenced by consumer demand for food. It provides key conclusions on methodologies for measuring household environmental impacts and proposes a list of indicators that could support research and policy analysis to promote less environmentally damaging food consumption patterns.

Section IV discusses the policy implications for reducing the environmental impacts from household food consumption and identifies questions that were not addressed in the national case studies but which have a bearing on policy design to reduce the environmental impacts of food production and consumption patterns. The case studies raised other issues that are important for determining the net environmental impact of food consumption patterns.

2. HOUSEHOLD FOOD CONSUMPTION PATTERNS

2.1 Food Consumption Trends and Projections

This section of the report examines OECD household food consumption patterns and how those trends are expected to develop over the next twenty years. The discussion covers household demand for major food groups (meat and dairy products, fats and oils, fruits and vegetables, flour and cereal products, sweeteners, and beverages) and food services (shopping, out-of-home food preparation for at-home consumption, restaurants), and briefly indicates significant links of each food group or service to environmental impacts. The discussion then outlines the economic, demographic, social and other factors driving household food demand. This section also highlights, but does not discuss in depth, changes in the structure of the food processing and retail/distribution sectors that have a direct or indirect influence on household food consumption patterns.

2.1.1 What we eat: food consumption trends and projections

OECD household diets have changed in important ways over the last three decades. Despite sometimes significant differences in per capita consumption of major food categories (Table 1) the four case study countries share a rising trend toward higher consumption of meat (except Poland), cheese, fruits, vegetables and bottled drinks, and a declining consumption of fluid milk and potatoes (Figures 2 a,b,c,d). These trends mirror those in other OECD countries, although a few (e.g. Mexico and Korea) have not reached saturation levels for per capita consumption of individual commodities and/or aggregate food consumption (Alexandratos 2000). Total calorie intake through high-fat, energy-dense diets is also increasing in many OECD countries. In some countries this, and increasingly sedentary lifestyles, are leading to rising obesity levels. The US Department of Health and Human Services, for example, estimates that 35 percent of US adults are technically obese, up from 25 percent in 1980, despite a generally positive response to nutritional guidelines issued by the government. The nutritional benefits of eating leaner meat and drinking lower fat milk are being compromised by increases in caloric sweets, high fat dairy products, especially cheese added to processed foods, and near record amounts of added fats including salad and cooking oils, and baking and frying fats. (Kauffman and Chevrot, 2000).

Table 1 Per capita consumption of major food categories (kg/capita/year)

	Total	Meat	Eggs (no)	Fats and oils	Fruits	Vege-tables	Flour & cereal products	Sweeteners
Austria	764	94	na	na	87	94	79	41
Poland	790	86	177	16*	54	263**	119	42
Sweden	750	72	na	na	56	103	71	na
US	907	89	239	134	134	189	91	70

Data are for 1998 (estimates for Sweden)
* Includes only fats and oils of vegetable origin; ** Includes potatoes

Total per capita meat consumption has increased in all case study countries, with the exception of Poland where the removal of consumer subsidies and reforms in the productive sector in the late 1980s altered meat production and raised retail prices (See Section 2.2). Beef consumption has declined while the demand for pork, and especially poultry, has risen. Poultry in frozen dinners in the US increased 28% between 1992 and 1997 while the number of companies preparing poultry meals increased by 31%. Poultry supply is expected to be the fastest growing component of meat supply in Poland over the next five years. Consumer health and nutritional concerns and the demand for convenience are major drivers of the demand for poultry and of the demand for cuts of all types of meat requiring less preparation time.

The demand for dairy products also shows a decline for some products, particularly fluid milk, and a steady increase in others, particularly cheese (up 27% in Austria and 17% in Sweden since the mid-1980s). In the US, health concerns that have led to the downturn in consumption of whole milk have not influenced the demand for cheese, which increased 2.5 times in the 1990s. Two-thirds of the cheese consumed in the US now comes in commercially manufactured and prepared foods -- a reflection of the trend toward convenient, pre-packaged foods and increased out-of-home dining. In Poland, substantial subsidies to milk made low-fat cottage cheese and fluid milk the cheapest source of protein in the 1980s. As in the case of meat, however, liberalisation of the food market has since led to higher retail prices and lower demand for milk products.

The environmental significance of household demand for meat and dairy products is primarily linked to upstream pressures from animal husbandry and meat processing. The environmental impacts of meat production include land use pressures from grazing and grain production for beef production and water pollution and animal waste management from feedlot production. The increasing consumption of poultry and pork has intensified environmental pressures from large-scale production of these sources of protein.

Fats and oils

All four case studies note higher consumer awareness of the nutritional benefits of a low-fat diet and a positive trend in the substitution of vegetable oils for animal fats in household diets. However, only the US case study provides additional information on added fats and oils as a separate consumption category in household diets. Added fats and oils include fats and oils used directly by consumers, such as butter on bread, as well as shortenings and oils used in commercially prepared cookies, pastries and fried foods. In the US, Americans' overriding nutrition concern in the mid-1990s with cutting dietary fat is apparent in recent per capita food supply data, which shows a modest decline since 1993 in the use of added fats and oils. Per capita consumption of added fats and oils declined by about 7 percent in the 1990s, although current intake levels represent a 25 percent increase since 1970. That increase is primarily linked

to the greatly expanded consumption of fried foods in food service outlets, a huge increase in the consumption of snack foods, and the increased use of salad dressings.

Figure 1a. Austria: Estimated Total household consumption of selected food items, 1970-1998

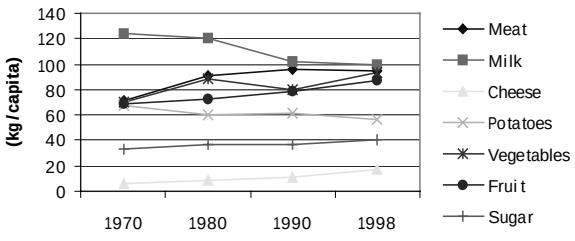
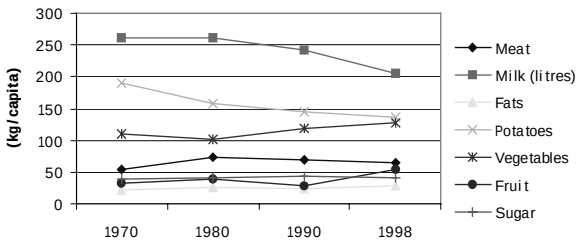


Figure 1b. Poland: Supply of selected food items available for human consumption, 1960-1998



1c. Sweden: Total household consumption of selected food items, 1960-1998

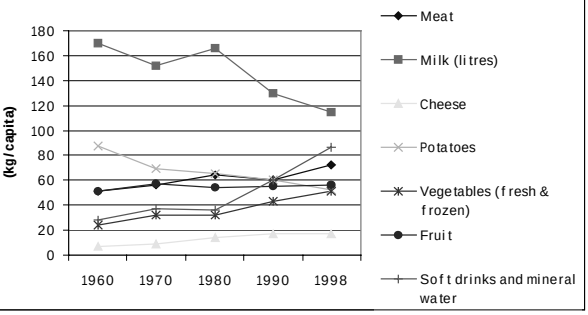
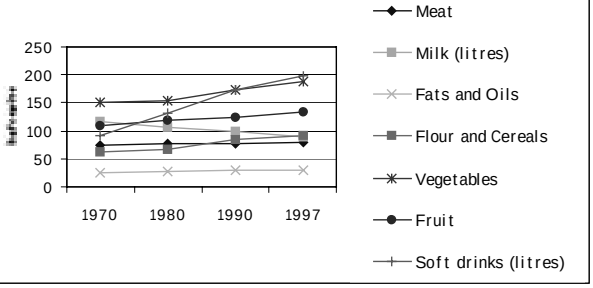


Figure 1d. US: Trends in total household consumption of selected food items: 1970 - 1997



The increased consumption of fats and oils is environmentally significant due to the energy-intensive processes used to produce them.

Fruits and vegetables

Per capita consumption of fruits and vegetables has increased, largely driven by consumer health and nutritional concerns, better quality, greatly increased variety, and year-round availability. In the US, for example, supermarkets today carry over 400 different produce items, compared to 150 in the 1970s.

Fresh fruit consumption increased since the mid-1980s by approximately 3% in Sweden, 24% in the US, 27% in Austria, and 88% in Poland. There has been an increase across countries in the quantity of fruit imported. In Poland, 25% of total fresh fruit consumption is imported. Similarly, a quarter of the fruit consumed in the US came from imports in 1991-1995, although consumer access to fresh, local produce also increased as the number of farmers' markets rose from 1,773 in 1993 to nearly 3000. An important area of growth in several of the countries is the demand for fruit juices which rose 42% between the late 1970s and 1997 in the US and 49% in Austria between 1983-1993 alone. The production of fruit juices in Poland showed very rapid growth in the 1990s: per capita fruit juice consumption grew 5-fold between 1990 and 1998.

Vegetable consumption has increased since the mid-1980s by approximately 59% in Sweden, 30% in Austria, 27% in Poland, and 19% in the US. In Sweden much of the increase has been in frozen vegetables and those having a low energy content (e.g. tomatoes, cucumbers). Polish consumption of vegetables, including potatoes, is distinctive due to the relatively low level of commercialisation of domestic production. In 1998, commercial production constituted about 57% of the total value of agricultural production (80% for animal production). Over 50% of individual farms operate exclusively or primarily to cover the food

needs of family members. The Polish diet is also unique due to the high content of potatoes (135 kg/capita in 1998) in relation to other OECD countries. In Poland, potatoes are still primarily consumed in non-processed forms despite the growing popularity during the 1990s of processed forms such as chips. In contrast, in the US the trend in fast food eating contributed significantly to the steep increase in the consumption of frozen vegetables (especially french fries) and tomato products.

The consumption of fruits and vegetables has a significant impact on the environment. Organic food waste from fresh fruits and vegetables is manifest throughout the food system from blemished and spoiled crops left in agricultural fields and orchards, through supermarket cuttings and trimmings, to household kitchen wastes. Other environmental impacts include land use and water pollution from the use of pesticides and fertilisers. Much of the non-point pollution of ground and surface waters of the American continent comes from agricultural run-off containing toxic pesticide residues and soluble fertilisers. Greenhouse production and road and air transport to meet consumer demand for year round availability are a third important area of environmental impact.

Flour and cereal products

Flour and cereal consumption has fluctuated in Sweden and generally risen in Austria. Per capita consumption in 1998 was 71 and 83 kg/capita respectively (EU average: 81 kg/capita). As with potatoes, Polish household consumption of flour and cereals is relatively high (119 kg/capita) and predominately includes bread and rolls. In the US increased consumption of flour and cereal products has been fuelled by a strong demand for variety breads and increasing fast food sales of products made with buns, dough, and tortillas. Per capita use of flour and cereal products reached 91 kilograms in 1997 from an annual per capita average of 66 kilograms in 1980 and 62 kilograms in 1970. According to the USDA (1998) the consumption of grain mixtures (lasagne and pizzas) increased 115 percent between the late 1970s and 1994. Consumption of snack foods (crackers, popcorn, pretzels, and corn chips) soared 200 percent, and ready-to-eat cereals increased 60 percent. A significant driver for this surge in the 1990s was the growth in preferences for ethnic (especially Mexican) foods in the United States. Frozen pizza sales grew from $1046.6 million in 1992 to $1617 million in 1997. Pasta used as ingredients in frozen specialities grew from $204.4 million in 1992 to $303.1 million in 1997 (US Census 1997). Both the US and Austrian studies note that consumption of flour and cereal products are predominated by refined and not whole grain products.

The environmental impacts of increased cereal and grain consumption are felt most directly from land-use impacts from agriculture and emissions from food processing. The impacts are greater for refined flours because more product can be extracted per pound of grain of whole-wheat flour.

Sweeteners

Only the US case study provides a detailed discussion of the consumption of caloric sweeteners in household diets. In the US, the consumption of added sugars and sweet-tasting foods and beverages increased 28% between 1982 and 1997. In 1997, per capita consumption of caloric sweeteners reached a record 70 kilograms – more than 53 teaspoonfuls of added sugars per person per day over 1982 levels. The source of that sugar has shifted from cane and beets to high fructose syrup – a shift primarily due to abundant corn supplies and low corn prices. Sugar is found in many foods, sometimes unexpectedly – such as pizzas, hot dogs, canned vegetables and sauces. An important driver behind increased sugar consumption is the increase in the consumption of carbonated soft drinks over the last 30 years.

A significant environmental impact of the increase in sugar consumption, especially in carbonated drinks, is the energy intensity of corn refining processes and wet corn milling.

Beverages

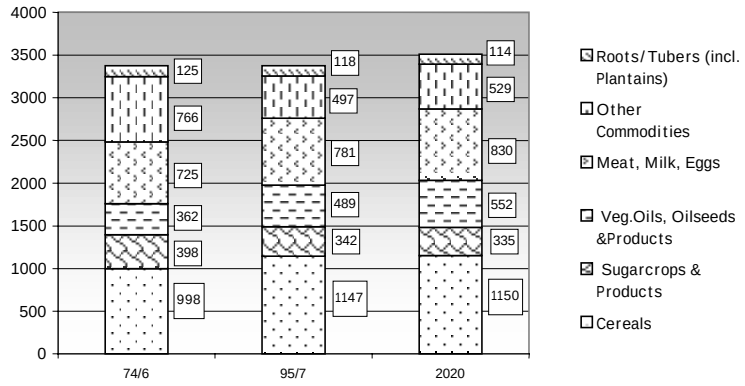
All countries note important increases in bottled beverage consumption, including fruit juices, mineral water, and carbonated soft drinks. In Sweden household demand for soft drinks and mineral water has increased 230% since 1970. In the US in the same period per capita consumption increased by 908% (from comparatively low initial levels) for bottled water and by 61% for carbonated soft drinks.

An important environmental impact from these trends is the disposal of beverage containers. Beverage containers are increasingly made from plastic, rather than glass or aluminium. In the US, only 5 percent of discarded plastics are recovered annually.

2.1.2 Outlook for Household Food Consumption: 2000 to 2020

Projected food demand for 2020 for the OECD region as a whole includes a 7% increase (from 95/95 levels) in per capita consumption of meat, milk and egg products and a 13% increase in vegetable oils, oilseeds and related products (Figure 2). Average total caloric intact will also increase. In Poland, the growth in demand will be highest for poultry meat, fish and fruit. A survey of firms and organisations in the Swedish food sector suggested that further growth is to be expected for processed and pre-prepared foods that are easy, predictable and quick to prepare. Pasta, rice and potato products, for example, will likely increasingly replace potatoes. Such considerations will also influence consumer preferences for vegetables so that tomatoes, cucumber and lettuce will replace beetroots, carrots and sweets. The Swedish survey also pointed to a decline in household food preparation skills.

Figure 2 Apparent Food Consumption in OECD Countries, Kcal/person/day, Major Commodities: 1974-2020



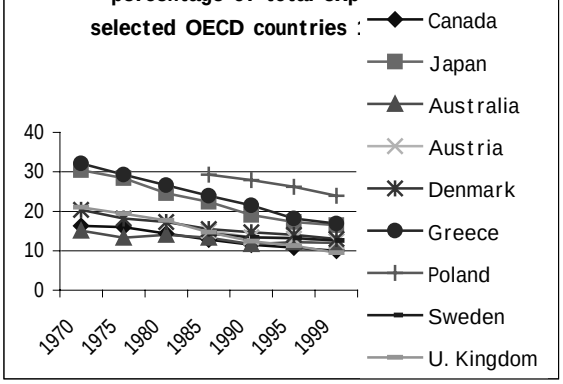
Source: Alexandratos, 2000.

A continued rise in consumer demand for variety will increase the demand for international products, both exotic and regional specialities. The demand for food perceived as healthy is likely to be another strong component of future household food consumption patterns, including organic foods and so-called “functional” or nutrient-fortified foods, and foods prepared or conserved in particular ways.

2.1.3 Consumer demand for food products and services and related changes in the food sector

Across OECD countries in general, and in the four case study countries, the predominant trend in household food demand is for an affordable and diverse food supply that is safe, of high quality and convenient. Consumer spending on food as a percentage of total household expenditure has steadily declined in most countries (Figure 3), sharpening competition in the food processing and retail sectors and leading to an explosion in the number of food products and services offered to the consumer. Changes in the structure of the food processing and retail sectors reflect these trends.

Figure 3 Household food expenditure as percentage of total expenditure: selected OECD countries



Source: OECD National Account, 2000.

Food products and services

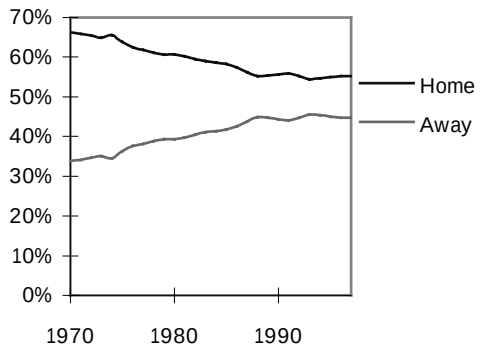
Food manufactures have reshaped the composition of the food basket in response to consumer desires for healthfulness, variety and convenience. New product lines and food processing industries have appeared. Americans, for example, choose from an average of 50,000 different food products on a typical trip to the supermarket. More than 16,000 new food products including new packaging sizes, flavourings, etc. were put on the US market in 1995, more than double the 8,000 introduced in 1988. In Poland, although the level of food processing remains lower than in the other case study countries, market liberalisation has opened the way to a considerable increase in the range of food products available and a larger proportion of value-added products. New food processing branches for soft drinks and fruit and vegetable juices were created in the 1990s. There has also been an important improvement in the quality, variety and attractiveness of traditional food products (bread, meat products, milk and milk products, jam, fish, confectionery, oils, and beer) in Poland.

Cross-cultural influences, consumer demand for variety and declining communication and transportation costs are leading to a "globalisation" of food consumption patterns and a growth in imported food products (e.g. fish, fruits, vegetables). Three characteristics seem to mark this globalisation trend. First is the appearance of a "globalised market kitchen" composed of an easy-to-survey number of ingredients and dressings providing nearly standardised tastes and culinary experiences all over the world (Schwendter 1997 in Payer 2000). Second is the growing range of different cuisines available to consumers nearly anywhere in the OECD region. Finally, there is the sustained interest in regional specialities and local production. In Austria and Sweden, for example, although the level of imported food products and interest in international cuisines is growing, there is still a demand for regional foods, tied not only to culinary preferences but also to health concerns related to food production techniques. However, a 1998 survey of food actors in Sweden projected that the demand for locally produced food would not be more than a marginal part of the food supply in the future.

A strong component of new product demand is for out-of-home food preparation and consumption. Pressed by time and a waning interest in food preparation, households increasingly demand frozen and chilled foods and pre-cut, pre-prepared meat, fruit and vegetables. These trends are also reflected in the growing percentage of household food expenditures spent on out-of-home food preparation, one of the most dynamic markets within the entire food chain. In Europe the food service industry is growing at 2-3% per year, against recent retail market growth of .5%. In Austria, approximately

25% of total household food expenditures go to out-of-home food sources and is expected to reach 30 to 40% (Payer et al 2000). More than a third of Austrians have their lunch outside the home, usually at work. Today, many Americans eat out (mostly in fast food restaurants) almost as often as they eat at home (Figure 4). Polish consumers are more traditional than households in other OECD countries with respect to the importance of in-home preservation and preparation of food. Nevertheless, although currently eating out is still relatively insignificant, particularly in rural areas, there are recent indications of a growing trend toward out-of-home dining.

Figure 4 US: Shares for food consumed at home and away from home



Source USDA, in Kauffman and Chevrot, 2000

A second important aspect of the demand for convenience is the rise of individual portions and packaging for many food products. This trend is closely linked with demographic shifts: the increase in the number of households, the growing individualisation of time budgets within households for both parents and children, and a steady decline in sit-down family meals. In Austria, for example, a remarkable number of household consumers eat alone, mainly at breakfast and dinner, when nearly 50% has no neighbour at the table. In Sweden, demand for single-serving meals has increased in volume since 1995.

The environmental impacts of changing consumer demand for food products and services are linked to the upstream effects in the food processing and distribution sectors and food retail service, including waste generation, air and water pollution, and energy consumption. The energy and pollution impacts from greater regional and global trade in foodstuffs are also important.

Food shopping patterns

In all of the case study countries the number of food retail stores has declined, while average store size has greatly increased. Larger multi-service formats help compete for consumers. In the US, the number of superstores has doubled since the mid-1970s while the number of "superwarehouse" stores has tripled. Although variety is more limited in the large warehouse stores, the price of non-perishable foods is generally lower than in conventional supermarkets. Trends are similar in Austria and Sweden (Table 2). In Austria, supermarkets and discount markets are now the most important source of supply for nearly all food categories, although meat and bakery products are purchased more frequently from specialised shops and local markets are still important points of purchase for fresh fruits and vegetables. Apart from these traditional forms of food shopping, however, a number of new options have begun to gain in importance in the last decade, namely petrol service stations, mobile delivery services, bookshops, food slot-machines and electronic commerce. The rate of online-shopping for food has increased remarkably, although not as fast as in other fields of electronic

Table 2 Sweden : Shops and sales shares, 1960-1997

	1960		1970		1980		1997	
	No. of shops	%	No. of shops	%	No. of shops	%	No. of shops	%
Supermarkets	25	3	800	30	1550	57	2060	77
Small shops	23000	97	12100	70	6200	38	2860	12
Service shops	0	0	35	<1	1250	5	2860	11
Total	**23000**		**13000**		**9000**		**7780**	

Source: Jedvall, 2000.

commerce, in part due to the difficulty of satisfying consumer confidence for the purchase of fresh foods (Payer et al, 2000).

Poland has begun to see a similar concentration of retail outlets in recent years. The first hypermarkets were established there in 1993 and now number 95, located primarily outside the largest cities. At 10% total retail food sales (22% with supermarkets) these new store formats have yet to capture the percentage of consumer sales they have in other OECD countries, but these figures are expected to change as new hypermarkets are opened. An additional 83 hypermarkets are expected to be opened by 2002.

The primary environmental impact from the change in shopping patterns is from freight and personal transport. In Sweden, one study has shown that when there is a large hypermarket in the vicinity, almost a third of the area inhabitants will use it as their first choice for shopping. This study also showed an increase in household car travel linked to hypermarket shopping. Another Swedish survey showed that car travel for food shopping increased in a number of Swedish towns by a factor of 10-100 when a large hypermarket was established in the vicinity. The increase was greater in those cases where the supermarket was established far from an urban area. Interestingly, it is apparently common practice for hypermarkets in Poland to offer their customers free transport, which may help attenuate transport impacts. In Austria, food shopping is the only area of household shopping where a considerable amount of is still done by foot, primarily where shops are located close to home. However, although there are no statistics available, transport analysts agree that the importance of pedestrian shopping for food is declining. This trend is driven by a number of factors, including changing family structures, an increasing premium placed on convenience, and the continued disappearance of local food stores. The sharp drop in local grocery stores means that 300 municipalities in Austria have no local food supply. There is a potential for gains in transport efficiency (See Section 3.2.2).

Changes in the food sector

The entire food product system is made up of highly heterogeneous and complex a chain of actors reaching from the industries providing the inputs to agriculture, through the food production, processing, distribution and retail sectors, to final consumers and waste disposal infrastructures. The food sector is one of the largest economic sectors in each of the four case study countries. It is an important source of employment and strongly connected to other sectors of the economy (e.g. the engine building industry, the fertiliser industry, the packaging industry, public utilities and sometimes tourism).

The agro-food sector has undergone substantial changes across OECD countries over the last 30 years. Demographic, economic, and social shifts in the consumer market strongly affect the parameters within which the food industries operate at all levels (Manchester, 1992 in Kauffman and Chevrot 2000). Food industries need to provide a variety of products appealing to the consumers in a competitive environment and have hence intensified marketing activities such as focus groups or advertising so as to increase sales.

The search for efficiency and international scale in a mature industry has led to the consolidation of food processing firms. Economies of scale provide incentives for mergers and consolidation of firms, decreasing the number of firms and increasing market concentration. Mergers have been a major force in changing the organisation of food manufacturers. Large companies increasingly handle a broader line of products and either own or strongly influence firms in the upstream and downstream sectors of the chain. In Sweden, for example, over 80% of the dairies and distribution centres closed between 1960 and 1994, the result of a trend toward centralisation and large-scale operations. Entry into the European Union in 1995 has forced further significant changes in the Swedish food sector to meet the increased competition from other EU-countries. Vertical integration and consolidation has helped keep food prices low.

Changes in the Polish food sector have been even more dramatic. Decades of government intervention to maintain low retail food prices while simultaneously stimulating agricultural production through elevated producer prices eventually led to an unstable food market, and finally to empty shelves in food stores. The food market was liberalised in the early 1990s, along with the abolishment of most consumer subsidies and prohibitive taxes on wages and salary. Liberalisation initially led to a widening gap between food prices and per capita income but has also shifted consumer demand for certain products. As a direct result of liberalisation, the choice of food products in Poland has increased tremendously: popular items, which were previously difficult to buy, are now widely distributed. New products have been introduced as both Polish food manufacturers and foreign food manufacturers with direct investments in Poland have begun to extend their product ranges. A wide range of food products, such as citrus fruits previously available only at specific times of the year, are now available yearlong. The quality of food products and the range of food packaging have also increased significantly as food producers face increasing competition and an increasingly discriminating consumer.

Changes in the structure of the food sector can have both positive and negative environmental impacts. The trend toward centralisation and large-scale operations in combination with liberalisation of food markets has had a definitive impact on food distribution patterns and thus on energy and transport. The shift to more processed food and out-of-home meals in the average household diet also has an impact on energy use and the generation of organic and packaging waste both upstream in the food processing, distribution and services sectors and in the household. The net environmental impacts of these changes are discussed further below.

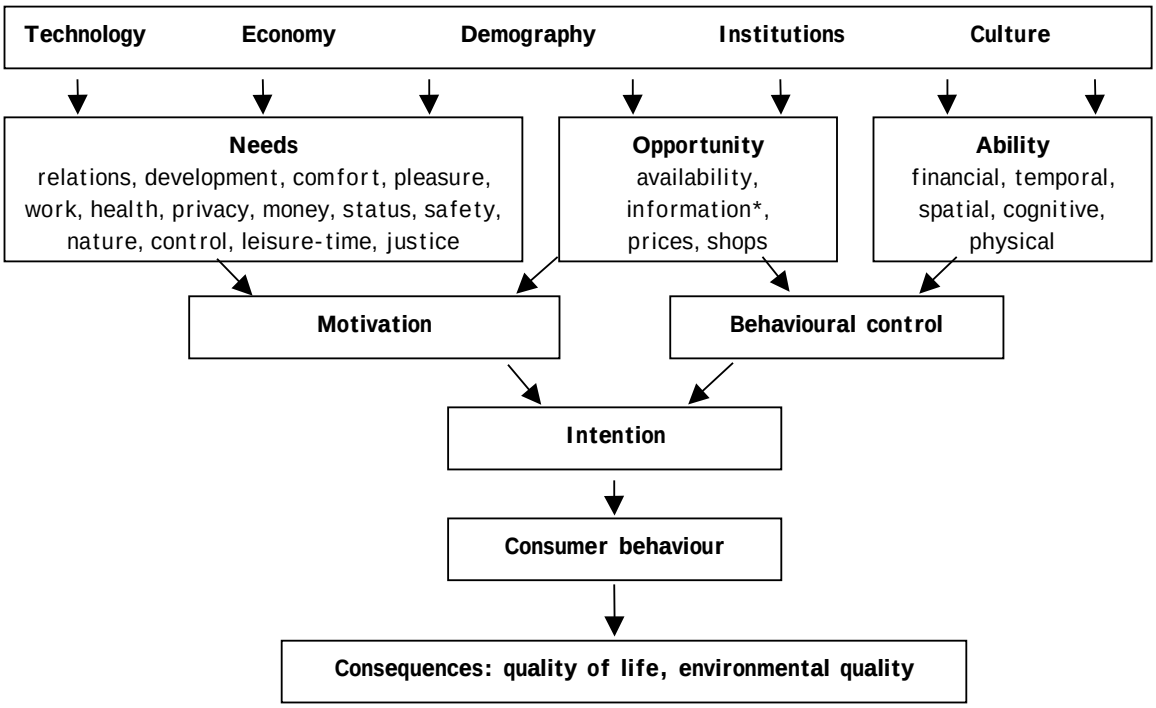
2.2 Driving factors behind household food consumption patterns

Household food consumption patterns are the product of a diverse set of driving factors that shape the day-to-day and long-term decisions that consumers make. It is possible to outline and group these driving factors in a number of ways, probably none of which captures each and every factor neatly without overlap or omissions. The outline used here draws from the US case study and the Needs, Opportunities and Abilities (NOA) model developed by Vlek et al (Gatersleben and Vlek, in Noorman and Uiterkamp 1998).[1] The NOA model is intended to provide a diagnosis of the specific factors underlying consumer behaviour at both the macro-level of society as a whole and at the micro-level of the household (Figure 5).

[1] The NOA model was inspired by the Motivation-Opportunities-Abilities (MOA) model of consumer behaviour (Robben and Poiesz, 1992; Ölander and Thøgerson 1994). To be able to better predict intentional consumer behaviour Ölander and Thøgerson extended the Fishbein-Ajzen theory of reasoned action (Fishbein and Ajzen, 1975) to include opportunity and ability components (for a full description see Gatersleben and Vlek, in Noorman and Uiterkamp, 1998).

Figure 5 The Needs-Opportunity-Ability Model of Consumer Behaviour

Needs and opportunities together constitute the motivation to buy something, while opportunities and abilities together constitute the behavioural control needed to be able to buy. The model builds on the means-end chain theory (Reynolds and Guttman, 1988; van Raaij, 1994) according to which people do not want goods for their own sake, but for what they can do for them. People therefore buy certain goods in order to satisfy their needs, which might be satisfied in another (e.g. less energy-consuming) way as well (From Gatersleben and Vlek, in Noorman and Uiterkamp, 1998).



2.2.1 Needs, opportunities and abilities shaping household food consumption patterns

The discussion below outlines some of the key driving factors that influence household food consumption patterns, using the NOA model as an organising framework (Table 3). Technology, demographic and cultural influences on consumption are not treated separately, but integrated into the discussion of needs, opportunities and abilities.

Table 3 The NOA model and household food consumption		
Technology (food production, preparation and conservation), **Policy** (regulations, information) **Demographics** (household size, employment), **Culture** (Gender, religion, age)		
NEEDS	**OPPORTUNITIES**	**ABILITIES**
Nutrition and Health	Food prices	Per capita disposable income
Convenience	Food products and services available	Education and Information: Nutrition, Exposure to food and food preparation skills, Environmental awareness
Variety	Advertising	

Needs

Nutrition and Health

At the most fundamental level we eat to live. Food is the main source of energy for human metabolism, and healthy diets can reduce the risk for a number of diseases, notably cardio-vascular illnesses and some cancers.

Among the demand for new products in many countries is the rising interest in foods perceived as healthy. Both the US and Austrian studies note the new wave of health consciousness in household diets which has led to a shift from " taking the bad out" – demanding foods with less salt, less fat, and fewer calories – to looking for food with added benefits. In Austria, for example, while five years ago nearly 33% of adult men and women said they used calorie-reduced foods regularly, only 14% consumed so-called "light" products in 1998. Now the focus is on nutritionally fortified foods: iodised salt, fortified fruit juices, breakfast cereals and sweets, and enriched dairy products are the most frequently consumed products of this class. A new category of "functional foods" that meet specific needs, fight disease or promote longevity is also attracting consumer currency with products such as probiotic yoghurts to promote intestinal health. In the US retail sales of dietary supplements exceeded 10 billion USD in 1996, with consumption growing from 71 million users ten years ago to between 94 and 130 million users today. Functional foods are far outpacing growth in the total US food market: nutritionally enhanced products account for 78% of total growth in more than 35 major food categories. The US study also notes a greater demand for animal product alternatives such as vegetarian burgers, soy and rice milk, cheese alternatives and non-dairy desserts that did not exist 40 years ago.

Food safety is a major concern across all the case study countries and a driver of food choices. A range of food safety problems in the last few years has focused consumer attention most on residues and contaminants from food production or processing systems, followed by additives. The Austrian study points out, however, that consumer fears do not take into account the higher risk that food scientists attribute to nutrition behaviour, pathogenic micro-organisms due to poor hygienic conditions, including in the home, and natural food toxins. A general drop in confidence in the arguments of experts, poor information policy of food producers, a growing suspicion of processed products and frequent food scandal headlines in the media have been important influences on consumer perceptions of food safety, and have led many to pay increasing attention to criteria of freshness, origin and minimum processing.

Food safety concerns have largely driven the growing demand for organically produced food. In the US, retail sales of organic products averaged a growth rate of 20% between 1990 and 1996, although organic foods remain only a marginal part of total food sales (2% in 1997). Although the price differential for organic produce is a dissuasive factor for some consumers, another reason for the low penetration of organic produce is consumer confusion over what is, in fact, organic. In Sweden, demand for organic food has also grown, but like in the US, remains marginal despite a clearer labelling system. Demand appears to be stronger in Austria, where more than 50% of all consumers use, at least occasionally, organic food products. 89% of Austrian consumers -- higher than the European average -- want to be informed in detail about the origin of the products they buy, and more than 80% want information about the use of genetically modified organisms (GMOs), treatment with irradiation, animal welfare, organic and other production methods. Other factors have contributed to the stronger support for organic food in Austria, such as: the entrance of the big chain stores into the organic food business, a skilful restructuring of the umbrella organisations representing organic farmers, and a strong boost in public subsidies to organic farmers after Austria's accession to the EU.

Convenience and Variety

One of the most important demographic shifts that has influenced changes in the food industry over the last thirty years is the increase of women in the labour force: in 17 OECD countries more than 75% of women between 25 and 44 now work, compared with roughly 40-60% in 1970. The conditions of the working day have also changed, with longer distances between the home and the workplace and continuous "9-5" working hours. These trends have created time conflicts for many families, particularly where cooking remains a primarily female task.[2] The evolution of the work and school day in OECD countries and related activities (e.g. commuting, after-school activities) have led to a splintering of the day into many short blocks of time during which multiple tasks must be accomplished. Time budgets have also become more individualised within households. While cooking may remain for some households an enjoyable pastime on the weekend, and still takes more traditional forms in Poland, in many other countries meal preparation time during the working week has dropped steadily. In US households where all adult members work outside the home, for example, the time allotted for meal preparation has shrunk from 30 minutes a few years ago to 20 minutes or less today. In the US and Austria, decisions about what to cook are often made only late in the day increasing consumer demand for food products that are fast to prepare and give predictable results.

More money and less time for food procurement, preparation, and consumption in many households have made convenience the key. The freezer and particularly the microwave have become standard household appliances. The widespread adoption of these technologies allows households to rely on pre-prepared frozen and chilled foods requiring minimum planning and preparation time in the home. Individualised portions and packaging meet needs created by individual time constraints and differing tastes. The food-processing industry has responded to these needs by developing new products that will meet consumers' demand for taste, quality, convenience and food services (mobile delivery services, home meal replacement, etc.).

Opportunities

In order to fulfill their needs, consumers must have both the opportunity to do so and knowledge of alternatives. Across the case study countries, the opportunity "landscape" is a significant driver of household food consumption patterns. Food is relatively inexpensive, and food products are abundant, and generally available year-round. Consumers are informed about their food options through a variety of

[2] Both the Swedish and Austrian studies note that meal preparation remains primarily a task for women.

means from government education and other information initiatives (media) on nutrition and dietary recommendations to brand and generic advertising.

Food Prices

An abundant supply of food, food sector consolidation, related economies of scale and smoothed demand, and improvements in transport and communications have helped keep food prices relatively low in many OECD countries. In both Austria and Sweden, entrance into the EU influenced price levels; the price of meat in Sweden, for example, has decreased 20% [since 1990] with most of the price reduction taking place after 1995 when Sweden became a Member of the EU. While average consumer prices increased 24.3% between 1990 and 1999, food prices decreased by 1.3%. In Austria, households also spend less on food than in the past. The Austrian study, however, also notes the polarisation of the Austrian food market into an expanding low-budget sector with extreme price competition and a growing higher-priced sector of higher quality products (delicatessen, regional brands, products offering any additional benefits).

Table 4 Food subsidies in Poland, 1970-91 (billion zlotys)

	1970	1975	1980	1985	1988	1989	1990	1991
Total food subsidies of which:	7.5	51.3	163.9	310.3	1,439.4	3,449.8	1,548.2	37.8
Meat and products	-	23.8	70.1	65.3	453.2	1,233.5	57.4	-
Milk and products	0.7	9.5	44.1	132.8	616.7	1,417.0	1,434.2	-
Cereal products	5.6	6.7	17.8	77.4	265.1	486.7	27.1	-
Sugar	-	4.7	13.1	7.7	39.0	96.6	-	-
Fish and products	0.5	3.8	12.6	7.9	6.9	5.2	-	-
Vegetable fats and oils	-	0.9	2.2	15.4	50.3	188.6	2.6	-

Source: GUS, Warszawa in Sekula, 2000.

In Poland, maintaining low food prices was a central political objective during the 1970s and 1980s. During that period government subsidies to meat and milk and milk products (Table 4) kept prices for those goods artificially low and allowed more affluent diets for many Polish households. The proportion of state subsidies to food increased from 19% in 1985 to 34% in 1988, increasing the contribution of food subsidies to food expenditure from 15% to 30%. After liberalisation of the food market in 1989/1990 consumers faced very rapid increases in food prices not matched by comparative wage increases. As a result, consumers demanded less butter, meat and milk and shifted to less expensive meats such as poultry.

It is important to note that while product prices and the price of substitute products, along with disposable income, can explain much of the annual variation in per capita consumption, they primarily explain choice of one product over another, and shifts to different groups of food products (e.g. to higher value-added products). Price and income alone will not lead consumers to choose a meat-intensive diet over one rich in other sources of protein. Income and prices are among a much richer texture of social and cultural beliefs and technological realities that motivate consumer behaviour. Evidence of this is present in

the changing demand for beef in the United States, which has declined since the mid-1970s. One reason for this decline is that chicken has become more affordable relative to beef. However, income changes would have contributed little to per capita beef purchases (only a 1% increase) because declining demand is primarily for specific cuts for beef that take more time and effort to prepare (such as roasts) (Manchester 1999 in Kauffman and Chevrot 2000).

Food Supply

The discussion in preceding sections underlines the abundance and variety of the food supply in OECD countries. The vast majority of households in the case study countries are food secure – they have assured access at all times to enough food to lead an active healthy life. Although there are households with food security problems - nearly 10% of US households (10 million) are food insecure at some point of the year and 21% of Polish households surveyed can afford only the cheapest food available - these problems stem from insufficient disposable income and not gaps in the food supply. Most consumers have a very wide choice of both low and high-priced food goods and services to choose from. Poland is unique in the still relatively high level of individual farm and home production of food for own consumption. This production explains food consumption data showing higher consumption of vegetables and grains, lower levels of consumption of imported fruits, and higher overall food consumption levels in rural families compared to urban families of the same size (Table 5).

Table 5 Poland - Per capita monthly consumption by household location

	Unit	Urban	Rural
Bread	kg	6.43	8.02
Pasta	kg	0.33	0.29
Flour	kg	0.99	1.71
Groats and flakes	kg	0.48	0.53
Meat	kg	5.27	5.73
Fish	kg	0.41	0.32
Liquid milk	l	5.08	7.55
Cheese	kg	0.92	0.76
Hen eggs	no.	14.13	16.17
Visible fats, total	kg	1.54	1.73
Fruit	kg	4.09	3.52
Vegetables	kg	5.44	6.16
Potatoes	kg	7.69	9.57
Sugar	kg	1.59	2.33
Source: Household Budget Survey			

Advertising

Food advertising is one avenue through which consumers receive information on different food options. In the US, food manufacturers spent $7 billion on brand advertising in 1997. Most of this advertising focused on the highly branded processed and packaged foods or soft drinks. The most advertised foods in the US are also the most over-consumed from a nutritional perspective. Fruits and vegetables, which are little advertised, are consumed in lower amounts than recommended. Brand advertising contributes largely to building the consumer culture. In the US, food marketing is the second largest advertiser and the leading supporter of network, spot, and cable televisions, newspapers, magazines, billboards, and commercial radio. Groceries account for about 70% of all manufacturers' coupons. Government efforts to provide consumers with information on how to improve diets compete with the food industry's massive spending. Combined education, evaluation, and demonstration initiatives by the US Department of Agriculture in 1997 amounted to $333.3 million – slightly more than half of what is spent annually on advertising for carbonated soft drinks.

Generic advertising to promote consumption of a general commodity has been used in the US by cooperative efforts among producers of specific food items, such as California prunes, Wisconsin cheese, beef in general, and by the US government to promote fluid milk consumption. In the US, generic advertising did have a positive impact on both cheese and fluid milk sales in the period 1984-1996. Research results are mixed on the impact of generic and brand advertising on beef consumption.

Poland saw a tremendous increase in food advertising in the 1990s. One of the most intensively advertised products was margarine - one product in the vegetable fats and oils category that has grown steadily. According to a recent Polish study, approximately 67% of consumers surveyed reported that advertising influenced their buying behaviour, with the greatest impact on the purchase of confectionery and beverages (Sekula, 2000). The Austrian case study reports a much lower awareness of food advertising: in a study there 60% (compared to 37% in the EU) reported that they relied on labels as the best way of informing themselves about the characteristics and nutritional content of food. Only 9% reported advertising, 8% brochures and 4% newspapers when asked for other sources for food-relevant information.

A report by Consumers International examined the wide diversity in the practice and regulation of television advertising to and for children, with special emphasis on food advertising in thirteen OECD countries, including Australia, Austria, France, Sweden, the UK and the US (Consumers International, 1996). Children are seen as needing special consideration with respect to advertising because they are less able than adults to understand fully the intent of advertising or its persuasive techniques, and are therefore less able to judge it critically. The extent to which such considerations are enshrined within regulations or codes of practice varies considerably. For example, Sweden and Norway do not permit any television advertising to be directed toward children under 12 and no advertisements at all are allowed during children's programmes. Food advertising comprised the largest category of advertised products to children in virtually all countries; confectionery, breakfast cereals (mainly sweetened) and fast food restaurants accounted for over 50% of food advertisements. Advertisements for fruits and vegetables were either non-existent or extremely few in number. The food consumption patterns of children are important in view of the fact that food preferences are often shaped during the early phases of life and influence individuals' food demand thereafter (Carlsson-Kanyama in Jedvall 2000).

Abilities

The ability of a consumer to satisfy needs given the knowledge and accessibility of different food products and services depends on disposable income, education (meaning an ability to interpret different types of information about a product) and information. Noorman and Uiterkamp also talk about the temporal ability to meet needs. Earlier discussions have already noted the growing squeeze on household time budgets in their purchase and preparation of foods. The discussion in this section will focus on per capita disposable income and education and information.

Per capita disposable income

Across OECD countries in general, per capita income has increased steadily. In Sweden, household consumption is increasing at a rate not seen in some time: 4.1% in 1999 with projections of 3.6% and 3.1% in 2000 and 2001 respectively. The reasons behind this strong consumption trend are that more people are working, confidence in the future is stronger than in the past, and inflation is low. The cost of living is somewhat lower than previous years. As a result, the buying power of Swedish households has increased. Although the consumption of food has remained relatively stable from year to year, the rise in per capita disposable income and lower food prices have allowed a strong shift to foods with higher value added (e.g. pre-prepared). In Austria, greater per capita income, combined with rapidly multiplying food options, has promoted more consumer behaviour driven by specific situations or events rather than by traditional determinants of food choices such as education or profession. Although household income remains an important driver of food consumption patterns, premium products are not accessible only by the wealthy; even lower-income household demand high priced products (e.g. wine, champagne, ham) for special events.

In Poland, despite rapid GDP growth in the 1990s, per capita income is among the lowest in OECD countries (7,487 USD). The share of total household expenditure going to food is relatively high at 23.6% and at 28.9% including alcohol. Food consumption patterns differ by socioeconomic group although the prevalence of farm or home production for own consumption allows some households in lower income groups relatively high levels of consumption of milk, eggs, non-imported fruits, and vegetables (Table 6). In 1998, employees' households with the highest income consumed four times as many high-grade meat products than those households with the lowest income, and two-and-a-half times as much fish, cheese, butter and fruit.

Income is also an important determinant of out-of-home consumption. In the US, dual-incomes combined with less time for meal preparation have sharply increased the number of meals consumed outside the home. The same effect is seen in Austria where only 18% of consumers with a household net income up to 15 000 ATS (USD 9450) frequently eat out of their homes compared to 47% of people with a household net income over 30 000 ATS ($18 900).

Table 6 Poland - Average monthly food consumption by the socio-economic household groups, 1998

			Household groups (from lowest to highest average income)					
Products	Unit	Total house-holds	Living on unearned sources	Farmers'	Employees farmers'	Employees	Disabled persons, retired	Self-employed
Bread & cereals	kg	9.67	9.12	11.3	10.46	8.44	11.61	7.83
Meat	kg	5.45	4.39	6.64	5.42	4.87	6.40	4.98
Fish	kg	0.38	0.26	0.33	0.29	0.36	0.49	0.38
Liquid milk	l	6.04	5.06	9.54	7.32	4.31	8.00	4.59
Cheeses, total	kg	0.86	0.60	0.77	0.77	0.81	1.05	0.88
Hen eggs	no.	14.93	12.51	18.95	15.99	12.73	18.16	12.42
Fats	kg	1.62	1.46	1.76	1.62	1.42	2.06	1.27
Fruit	kg	3.87	2.69	3.76	3.57	3.59	4.68	3.92
o.w.: fruit, fresh	kg	3.79	2.64	3.71	3.51	3.49	4.60	3.80
o.w.: imported fruit	kg	0.83	0.54	0.42	0.47	0.89	0.96	1.13
apples	kg	2.01	1.56	2.15	1.94	1.82	2.45	1.78
Vegetables	kg	14.14	12.46	16.82	15.21	11.58	18.55	10.98
Sugar & confectionery	kg	2.27	1.78	2.87	2.51	1.84	2.92	1.80
Mineral waters	l	0.82	0.44	0.20	0.35	0.90	1.00	1.28
Fruit and vegetable juices	l	0.68	0.47	0.19	0.27	0.86	0.55	1.33

Source: "The 1998 Household Budget Survey". GUS. Warszawa. in Sekula. 2000

Education and Information

Consumers in OECD countries are on the whole educated and literate. Moreover, they are exposed to a tremendous flow of information on food from many sources including government, consumer advocates, food manufactures and special interest groups.

Education levels are important to food choices from both a nutritional and environmental point of view. In Sweden, for example, men with higher education eat less sandwich fat and potatoes and more fruit, vegetables, pasta and fish than do women with less education. More highly educated people also tend to be more active information seekers. It is interesting to note that higher education levels do not necessarily translate into practical skills: the Austrian, Swedish and US studies all note a higher reliance on pre-prepared food and predictable dishes (e.g. pasta instead of potatoes) linked to the decline in general food preparation skills.

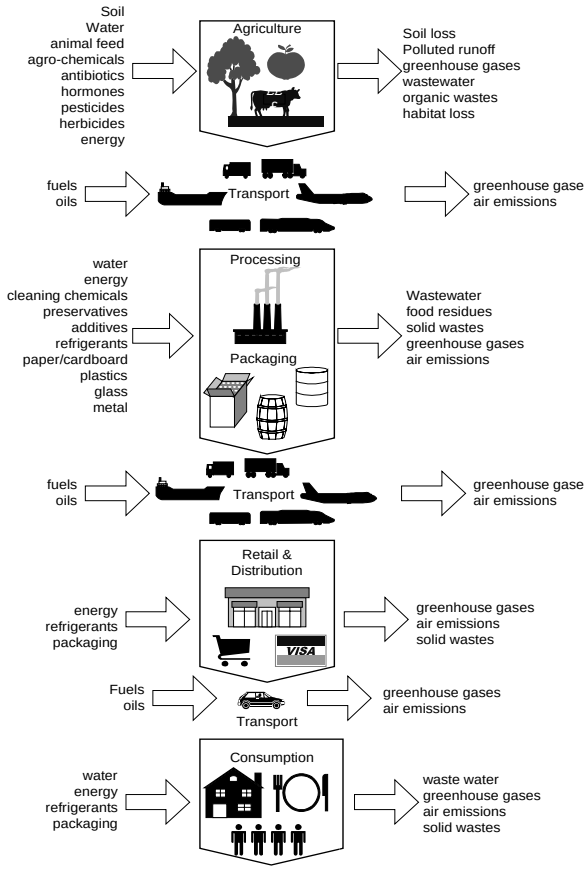
The focus of nutritional information has gradually shifted in OECD countries from nutrient-based recommendations - which required a perhaps unrealistic level of consumer expertise - to general guidelines which translate nutrient information into food groups. The food guide pyramid is a well-known example. Not surprisingly, the development of nutritional guidelines to date have not included the ecological dimension of food consumption, although rising consumer concern about food production systems may create pressure for guidance on food quality and safety that has ramifications for the environment (e.g. comparative studies on produce from organic, integrated, or conventional agriculture).

Information assimilation varies. In a Swedish survey, for example, 80% of the consumers surveyed believed that it was important to eat a healthy diet, and knew that the "Green key-hole" label indicated food with lower fat content. However, fewer people knew that that label also indicated food richer in fibre. Similarly, in Austria, although 44% of Austrian consumers report that they read food labels and/or data, and 80% feel that their level of nutritional knowledge is sufficient, the 1998 Austrian Nutrition Report showed partly very low levels of nutritional knowledge. These results indicated the need for specific information targeted to disinterested, passive groups. Given that written information will only reach well-informed and/or interested population groups, the use of the mass media was seen as an alternative for effective and objective information dissemination (Elmadfa et al in Payer 2000). In contrast, there is a high demand by consumers in Austria to be informed in detail about product origins, the use of GMOs, etc.; 96% of the Austrians surveyed wanted to find a declaration of origin on food labels. The burgeoning number of organic, GMO- and eco-labels, however, have created a dilemma for many consumers. Although labels can be effective tools for guiding consumer decisions, they are often unclear and can be misleading. Section 4.2.2 discusses this issue further.

3. ENVIRONMENTAL IMPACTS

The environmental impacts of household food consumption patterns depend on several factors, including where and how food is produced, processed, packaged, preserved, distributed, prepared and disposed of. The most significant environmental impacts are high in the production chain. However, OECD households influence trends in these areas through their choice of diet and their demand for food-related services. The demand for year-round availability of fresh fruits and vegetables, for example, has an impact through energy demand for greenhouse production or long-distance transport by either road or air. The growing demand for meat has led to intensive animal production systems for pig meat and poultry that are important sources of water pollution. Other impacts result from the food processing and services sectors (Figure 6).

Figure 6 Environmental impacts from the food sector



Source: Jedvall 2000.

Households also have direct environmental impacts related to how they purchase, store and prepare their food and how much organic and packaging waste they generate. The first part of this chapter describes the results of the national case studies focused in four areas: energy consumption for food preservation and preparation, transportation impacts from shopping patterns, food and packaging waste generation, and greenhouse gas emissions. In addition, the case studies pointed to some of the upstream links in the food production and processing sectors linked to changes in household food demand. Trends in energy consumption and transport in the food processing and distribution sectors and air and water pollution from food processing industries are discussed in the second part of this chapter.

The quantification of environmental impacts from household food consumption is a relatively undeveloped area of public policy research. In many cases, data are hard to find, or are collected at an aggregate level that makes it difficult to link household behaviour with a specific level of impact, and thus to define appropriate policy instruments. The information available from the case studies varies considerably in depth of analysis and data availability. Several methodologies have been developed and applied to food consumption analysis that can help improve the assessment of environmental impacts.

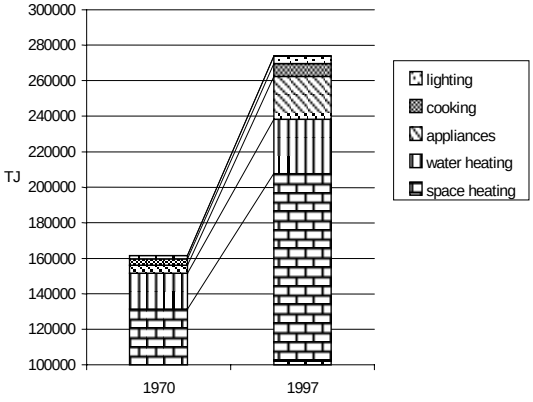
Section 3.3 provides key conclusions from a separate study on methodologies and proposes a set of 14 indicators that could be used to more closely monitor environmental impact trends in this area.

3.1 Direct environmental impacts from household food consumption patterns

3.1.1 Energy

Energy is an essential input to household activities related to food, including shopping, storing, preparing, cooking and cleaning. The use of energy for all of these activities constitutes an important, but not the dominant, component of total household energy use. In Austria food-related energy consumption (excluding fuel for transport) accounts for 7% of total energy (Figure 7). In comparison, the US study estimates energy use for cooking and washing dishes at 10% of all household energy and a Swiss study put food-related energy use at 12%.

Figure 7 Energy consumption in Austrian households, 1970 –1997



Source: Payer et al, 2000.

Food-related energy consumption is dominated by the use of appliances. The aggregate energy intensity of food-related technical equipment is determined by two factors: the growing efficiency and the number and capacity of the appliance stock. Although average efficiency has increased and should continue to increase, higher ownership levels and the increased energy consumption of bigger appliances have overtaken these gains (Table 7). This explains the net increase in energy consumption for cooking and appliances. In the US, technological developments in refrigeration spurred in part by efficiency standards and consumer awareness programs like EPA's "Energy Star" initiative can help to reduce this intensity. However, unlike many other appliances, ranges, ovens and stovetops are not subject to government minimum-efficiency standards, and manufacturers tend to concentrate more on styling and ease of cleaning than energy efficiency. Tests by the US Bureau of Standards have shown that some people use 50% more energy than others do to cook the same meal. In Europe, refrigerators, freezers, and dishwashers are required to carry energy-efficiency rating labels.

Table 7 Household Appliance Ownership: Early 70s to late 90s (Units per 100 households)

		Refrigerators/ Comb. Units	Freezers	Micro-waves	Dish-washers
US	1973	100	34	na	25
	1997	115	36	85	50
AUSTRIA	1970	67	11	0	1
	1998	97	67	45	44
POLAND	1973	na	na	na	na
	1998	96	R: 18-77	R: 5-32	R : 1-6
SWEDEN	1973	97	55	na	11
	1995	114	86	na	47

Source: IEA, October 2000; Payer 2000; Sekula 2000

In Poland, between 94% and 99% of households have a refrigerator, while percentages for freezers vary considerably, ranging from 18% in low-income households to 77% in farmers households, which

have mid-range incomes but produce much of their own food supply. A 1995 study showed that higher energy use for food preparation in farmers' households compared to employees' households was related to less efficient appliances (80% of farmers' households used coal stoves, compared to 35% in employees' households), longer cooking times and larger family size. The Polish national case study, however, recommends that these data be updated in view of a clear modernisation of household food appliances in recent years (Sekula 2000). Moreover, energy prices were liberalised in the 1990s leading to conservation measures by households. The prices of most energy carriers in Poland are now approaching price levels in the EU. Polish households spent on average 10.4% of total expenditures on energy in 1998, which is 2-3 times higher than households in other EU countries. Energy analysts estimate that more rational household energy use could lead to a 30% reduction in gas consumption. The use of microwave ovens is till low and dependent upon income: 5% of low-income households own a microwave compared to 32% of upper-income households.

One of the important questions to ask in determining the impact of household food consumption patterns on energy use, is the impact of the increasing percentage of foods prepared and/or consumed outside the home. The country studies did not explore these trade-offs in depth. However, several observations can be made. As food is being increasingly processed away from home, food processing needs more and more energy for its operations. In the mean time, the microwave oven uses far less electricity than conventional electric ovens, and is particularly effective for reheating meal. At the household level, this trend should generally translate into decreased demand for energy for cooking purposes. Nevertheless, even though home cooking decreases, household energy use will not significantly decrease because refrigerators and combination units (refrigerator/freezers) remain the highest electricity consumers. Any decrease in the use of electric ranges or the shift towards microwave heating will be small compared to the refrigerator bill (Table 8).

Table 8: US - Energy use per year for selected appliances

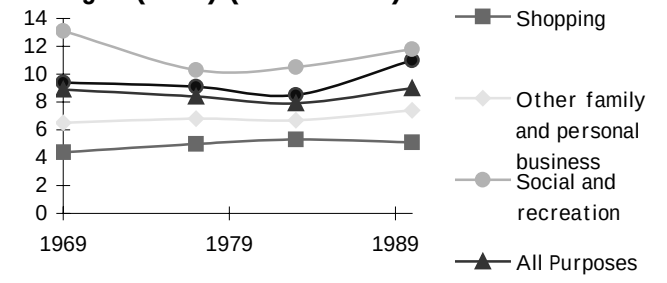
Appliance	Time in use	kWh/ year
Microwave oven	2 hours/week	89
Coffee maker	30 minute/day	128
Refrigerator (frostfree 16 cubic feet)	24 hours/day	642
Dishwasher (not including hot water)	1 hour/day	432
Refrigerator (frostfree 18 cubic feet)	24 hours/day	683
Toaster oven	1 hour/day	73

Source: US Department of Energy in Kauffman and Chevrot 2000.

3.1.2 Transport

The direct food-related transport impacts from household food consumption patterns are mainly related to individual passenger-car traffic. Data on the portion of total household demand for individual car travel that is devoted to food shopping is difficult to find. This is because household transport statistics are often not disaggregated by shopping purpose. Estimates for the case study countries include up to 10% of total household transport demand in Austria (Herry and Sammer 1998 in Payer 2000) and somewhat less than 4% in Sweden.

Figure 8 US: Average vehicle trip length (miles) ('000 tonnes)



Source: Franklin Associates, EPA (1997) in Kauffman and Chevrot, 2000.

Household food transport patterns is another area where potential trade-offs arising from shifting consumption patterns have not been fully evaluated. Section 2.1.2 discussed the evolution of food shopping patterns and the rapid increase in the number of hypermarkets and food shops, often located outside large cities and small towns. In order to assess the environmental impact of this trend it would be necessary to measure changes in shopping frequency against average distances travelled. While bigger store formats and larger home conservation appliances have led to a decline in shopping frequency in many countries, trends in shopping distances are not uniform. In the US, for example, shopping distances appear to be declining although the data are not disaggregated by shopping purposes (Figure 8). On the other hand, anecdotal information in Poland linked to a 15-fold increase in car ownership over the last 30 years (33-fold in the largest cities) and the creation of out-of-town hypermarkets suggests a growing portion of transport miles for household food shopping. In Sweden, one study concluded that for some goods households use almost as much energy in driving their food home as producers do in transporting it to the shops.[3]

3.1.3 Waste generation

Food Waste

Food losses begin on the farm and continue through the retail chain to the consumer. In the US, according to a study carried out by the USDA Economic Research Service more than 43.6 billion kilograms (27% of edible food available for human consumption in 1995) were lost by retailers, the food service industry and consumers. Food service and consumer food loss accounted for nearly all of the waste, with fruits and vegetables (fresh and processed) and fluid milk accounting for 50% of the total. Grain losses account for 15% and caloric sweeteners (12.4%) by weight. Food waste is comprised of leftover portions of meals and trimmings from food preparation activities in kitchens, restaurants, fast food chains and cafeterias. At the retail level, food waste results from overstocking, improper stock rotation, and the discard of seasonal foods, etc. US households generated 12.7 billion kilograms of food waste in 1995 compared to 11.8 billion kilograms in 1970. Food service and household food losses occur because of over stocking, over preparation, plate waste, cooking losses and misunderstanding of quality defects and label interpretation (such as "sell by" dates or expiration codes).

Table 9 Average food losses at the household level

	% of product net weight
Poultry	-55
Veal	-50
Beef	-48
Oils	-46
Butter	-45
Pork	-45
Fruits	-42
Cheese	-18

Source: Erard 1986, Östat 1995, in Payer 2000

In Austria, food waste is estimated to be the second largest component of discarded waste after construction waste. According to national material flow accounting[4] total food losses in commercial and household kitchens in Austria are estimated to be 1.9 million tons (Table 9). A Swiss study estimated that about 25% of total municipal waste in Switzerland is linked to food consumption patterns (Belz 1994 in Payer 2000). The volume of biodegradable waste (mainly food and garden waste) collected in Austria has increased: in 1996 an average of 46 kilograms per capita was collected in special waste containers. It is estimated that an additional 20% could be separately collected and earmarked for bio-technical treatment

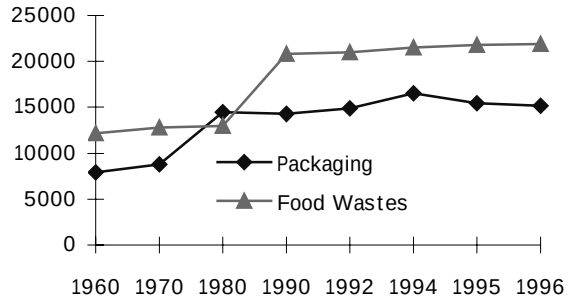
[3] The example given is the energy that is used to make a journey by car (fuel consumption is assumed to be one litre per 10 kilometres) to and from a shopping centre 5 kilometres away. This is the equivalent to the energy used to transport 5-10 kg of apples from New Zealand to Sweden by ship.

[4] See Annex 2 for a description of Material Flow Analysis and an example of its application to household food consumption patterns.

(FMEYFA 1998 in Payer 2000). A study of waste management in the Viennese food sector estimates the potential for residual waste reduction be more than 30% of current levels (e.g. via re-use in pork production) (Graggaber et al, 2000 in Payer, 2000).

In the US, food waste is the third largest component of generated waste (after yard waste and corrugated boxes). The amount of food waste in the waste stream has increased by 1.2 million tons in the last 25 years. Food waste has declined as a *percentage* of municipal solid waste, but this is due to increased tonnage in paper and other materials – many of them for food packaging (Figure 9). In the US, most of these wastes end up in landfills. Landfilled food waste has a density of 2000 pounds per cubic yard, other wastes have a much lower density (aluminium cans: 50-74), plastics: 24-400; cardboard: 300-1200). Food waste is the wettest component of the waste stream with typical moisture content of 70 percent and an energy conversion value for incineration ranging from 1500-3000 BTU per pound compared to the average 4500-5000 BTU/pound for municipal solid waste. Organic decomposition can also result in methane production, which contributes to global warming. Currently, only 4.1% of food waste in the US is recovered through food composting. This compares to a 41% recovery rate of yard waste through composting. Some states have set recycling targets for food, including California and some locales in Massachusetts.

Figure 9 US Food wastes and packaging wastes, 1960-1996 ('000 tonnes)



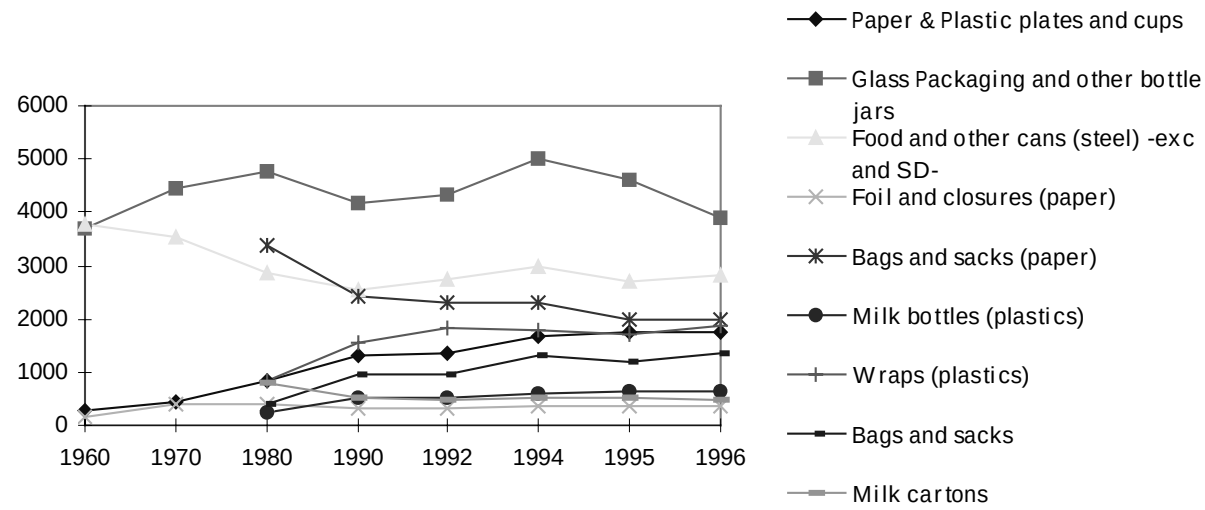
Source: Franklin Associates, EPA,1997 in Kauffman and Chevrot, 2000.

In Poland, there are no surveys focused directly on food waste. However, the National Food and Nutrition Institute has provided a rough estimate based on food data derived from household budget surveys. This estimate combines information on the percent of waste for individual food items derived from Polish food composition tables and estimates on plate waste in households. The results show that edible food waste in households amounted to over 100 kg per person in 1998 and ranged from approximately 96 kg in urban households to over 108 kg in rural homes.

Inorganic waste

The trend toward increased packaging for household goods, including pre-packaged foods and food service packaging has helped reduce food waste from spoilage, transportation and storage. It has also, however, significantly increased the amount of non-organic wastes entering the waste stream from household food consumption and diversified the materials (Figure 10). Recovery rates in the US for inorganic wastes have increased over the past 30 years but vary widely depending on the materials, ranging from 42% for paper and paperboard, 39% for metals, 24% for glass and 5% for plastics. The low recovery rate for plastics is of particular concern for reducing environmental impacts of household food consumption trends given the tremendous increase in consumption of carbonated soft drinks; plastics have progressively replaced glass and aluminium packaging in the soft drink industry. Thus, despite the fact that recycling and composting are at the highest levels ever in the US (31.5% -- nearly four times the level recorded in 1990 (bioCycle 1999 in Kauffman and Chevrot 2000)), wastes from household food consumption are among the least affected by these trends. Experts in waste management say that the infrastructure built to process recyclables and organic waste is more than capable of handling greater volumes but market forces (the lack of markets for recycled plastics, for example), political and budget imperatives stand in the way. Policies are emerging to promote the use of recycled products.

Figure 10 US: The evolution of packaging waste



Source: Franklin Associates for the USEPA, 1997 in Kauffman and Chevrot, 2000.

In Poland the evolution of packaging waste has not been studied in the past. The Polish Packaging Research and Development Centre made a preliminary estimate of waste generation for the Polish national case study. According to the results obtained, total packaging waste amounted to approximately 2.7 million tons in 1998 and included some 1.1 million tons of paper/cardboard, 427 thousand tons of plastic, 124 thousand tons of composite cardboard packaging, 165 thousands tons of metal packaging and 870 tons of glass packaging. Less than one fourth of this total was subject to recycling. Waste analysts estimate that approximately 60% of packaging waste come from food packaging and amounted to 33.9 kilograms per person in 1998. Glass and plastic packaging were the two most common materials in household packaging waste streams. Packaging of meat products, yoghurts and other milk products, margarine, vegetable oils, and mineral waters predominantly contributed to total plastic packaging waste. In view of the increasing trend in the consumption of all of these product groups, packaging waste is expected to be increasing as well. Fast growing consumption of fruit juices is also driving glass packaging waste increases. Estimates forecast a growth in the production and use of packaging materials in Poland in future years with total packaging waste reaching approximately 3.4 million tons in 2005. A waste management act was introduced in January 1998.

3.1.4 Greenhouse gas emissions

Household greenhouse gas emissions are related to direct energy consumption for food conservation and preparation, food transport patterns, and finally choice of diet through the upstream impacts on production, processing and distribution patterns. The US, Swedish and Austrian country studies include some information on the contribution of household food consumption patterns to GHG emissions.

According to a German study the distribution and consumption of food together account for 42% of all CO_2 emissions connected to the food sector (Table 9)(Enquete-Kommission in Payer 2000). In the US, the Union of Concerned Scientists analysed the environmental impacts

Table 9 Germany: Food system contributions to the greenhouse effect

	Million tons of CO2 equivalent	%
Agriculture	135	52
Processing	15	6
Distribution	35	13
Consumption	75	29
Total	260	100

Source: Enquete-Kommission, 1994 in Payer, 2000

from consumer decision-making using an Input-Output model.[5] This analysis covered annual emission of greenhouse gases (tons of carbon of CO_2, methane, and nitrous oxide) from production through consumption. This analysis showed that the combined consumption of meats, fruits, and vegetables contributes most to GHG emissions. However the trend in eating away from home (which includes factoring in transportation to and from food service establishments) is also a significant contributor to GHG emissions (Union of Concerned Scientists 1999 in Kauffman and Chevrot 2000).

Table 10 Nutrient content of some foods and the emissions of GHG per unit of nutrient

	MJ per kg	Protein (grams per kg)	β-carotene (µg per kg)	g CO_2 equivalents per MJ	g CO_2 Equivalents per g protein	g CO_2 equivalents per µg β-carotene
Tomatoes	0.83	9	5 730	4000	370	1
Carrots	1.67	6	68 000	300	83	0
Potatoes	3.10	18	100	56	10	2
Rice	14.90	68	0	430	94	-
Pork	7.20	180	0	850	34	-
Dry peas	12.40	215	150	55	3	5

Source: Carlsson-Kanyama, 1999.

Recent work using Lifecycle Analysis (LCA) in Sweden provides additional information on the choice of diets and related impacts on global warming (See Annex 2 for additional discussion and examples). Carlsson-Kanyama has compared different foods, their nutrient content, and emissions of GH gases per unit of nutrient (Table 10). This table also shows how conclusions about the highest or lowest emitting food depend entirely on the functional unit chosen (e.g. energy, protein, etc.). In related work by Carlsson-Kanyama four different meals with the same energy and protein contents were compared in terms of their GHG emissions. The four meals were: (a) purely vegetarian with ingredients primarily from domestically produced foods (carrots, potatoes, and dry peas); (b) purely vegetarian but with "exotic" products (rice, tomatoes[6]); (c) solely based on animal and exotic foods (tomatoes, rice, pork); and (d) including only locally produced foods of both animal and vegetable origins. GH emissions during the life cycle of the four meals differ substantially. The animal-exotic meal (c) emits 1800g of CO2 equivalents while the vegetarian-domestic meal (a) is nine times less polluting at only 190g of CO2 equivalents. However, this does not mean that vegetarian food is always less polluting than animal food. The vegetarian-exotic meal (b) maybe much more polluting in some cases than meals with animal ingredients (d) – for instance where production involves energy-intensive greenhouse production or when food is transported long distances. Based on this analysis, Carlsson-Kanyama also provides calculations of sustainable consumption levels related to GHG emissions based on a defined set of criteria concerning GHG reduction targets and the equitable distribution of anthropogenic GHG emissions (See Carlsson-Kanyama 1999 for a full discussion).

3.2 Indirect environmental impacts from household food consumption patterns

Food systems across OECD countries have responded to consumer demands by offering a wider variety of food products of consistently higher quality. What are the upstream environmental impacts from meeting that demand? The bulk of environmental impacts from the food system are connected to production systems and their impact on water quality, greenhouse gas emissions, soil conservation, air

5 See Annex 2 for more information on input-output models and an example of their use in assessing the environmental impacts from household consumption.

6 In this analysis, tomatoes are considered exotic because they either have to be imported from southern Europe or else grown in greenhouses.

pollution, habitat alteration and biodiversity. The environmental impacts of food production have been studied elsewhere in the OECD and are well documented.[7] This section highlights briefly some of the principal environmental pressures stemming from the food processing, distribution and retail sectors, which have received less attention to date in the OECD. Key environmental aspects related to these sectors include energy use, GHG emissions, discharge of high-strength effluents, localised odour problems, air pollution and chemical use and storage. The following discussion covers only a subset of these issues, but serves to underline the link between changes in household demand for certain food products and services and environmental impacts higher in the food system. From a policy perspective, this discussion is important for determining the most effective points for technological innovations or policy measures to reduce impacts given short- to medium-term household consumption patterns.

3.2.1 Energy

In view of the increasing demand for processed and pre-packaged foods, energy consumption in the food-processing sector is an important area for investigation. In the US, the food industry is a relatively important user of energy, ranking fourth in electricity consumption. A major portion of the fossil fuel consumed is used in the manufacture of steam, which serves four general functions: blanching and scalding, cooking, sterilisation and pasteurisation, and evaporation (concentration and dehydration). Food products are usually treated in batches but continuous processes for large operations have been developed. Blanching is the process of heating fruits and vegetables prior to freezing or canning in order to deactivate certain enzymes, to preserve color and flavor, to eliminate air from the products and soften the tissue to facilitate packing. Scalding refers to immersion of a food product in heated water. It is used in meat and poultry treatment and processing to preserve quality and facilitate cleaning. Frozen fruits and meat operations are relatively energy intensive (Table 11).

In the US, wet corn milling, is the most energy intensive process per value of shipment: most energy use is associated with evaporation of water from concentrate solution to produce sweeteners and starch. High fructose corn syrup captured most of the market for caloric sweeteners in beverages in the mid-1980s. Rising production of corn sweeteners for these beverages increased the demand for corn wet millers. Frozen fruits and vegetables are energy intensive due to the use of steamers for blanching and freezing processes described above. The meat and poultry industry also ranks high in overall energy consumption but is not especially energy intensive given the large number of products produced. The high total consumption results mainly from the volume of production which is driven by strong consumer demand. The primary energy consumption for meat and poultry occurs in refrigeration and in the rendering of by-products (Ouellette, 1980 in Kauffman and Chevrot). Another area of concern is the increased input of frozen products in the manufacture of frozen dinners, which increase considerably the energy share of the final product. In terms of environmental impact, the US national case study suggests that the trade-off between this method of food conservation and chemical preservatives should be considered.

[7] For information on projects and publications see the websites of the OECD Directorate for Food, Agriculture and Fisheries [http://www.oecd.org/agr] and the OECD Environment Directorate [http://www.oecd.org/env].

Table 11 : Energy intensity for selected food processing

Industry	Electricity purchased for heat and power (1000kwh)	Electricity generated less sold for heat and power	Shipments ($000)	kwh/$
Wet corn milling	6,902,497	1,876,208	7,188,399	1.22
Frozen fruits, juice and vegetable manufacturing	3,292,705	4,977	9,338,743	0.35
Flour Milling	2,166,089	10,789	7,881,131	0.28
Dry pasta	406,100		1,627,125	0.25
Ice cream	1,181,699		5,778,574	0.20
Rice milling	434,180		2,157,622	0.20
Soybean Processing	1,685,695	637,138	12,297,551	0.19
Dried and dehydrated food manufacturing	606,793		3,267,591	0.19
Frozen specialty foods manufacturing	1,746,047		9,518,344	0.18
Poultry processing	5,253,749	794	30,998,048	0.17
fruits and vegetable canning	2,001,492		15,924,097	0.13
Beet sugar manufacturing	700,954	369,828	9,338,743	0.11

Source: US Census, 1997 in Kauffman and Chevrot, 2000

In the distribution and retail sectors energy use is associated with warehousing and food refrigeration and fuel use by distribution fleets. A wide range of environmental practices is now available to retailers, from efficiency gains in the supermarket industry to recycling and refrigeration management programs. A study by the Food Marketing Institute (1999) in the US found that the primary benefits of such practices are improved customer and community relations, reduced costs, and regulatory compliance. But many companies find it difficult to implement environmental practices because of lack of time, expertise and knowledge of technological alternatives. Technical assistance programs by government and trade associations could improve this situation. For example, better understanding of the long-term savings and environmental benefits of alternative freezing and refrigeration from energy intensive and open equipment to environmentally friendly equipment could lead to reductions in the environmental impact of the supermarket industry. The trend towards fewer and larger retail outlets with centralised warehousing is aimed at increasing economies of scale, improving logistical efficiency and optimising transport distances, which also should improve energy efficiency. It is important, however, to determine the net effect of these trends, greater international distribution of foods (see below), and a possible increase in household travel for food shopping.

3.2.2 Transport

Transportation statistics for commercial freight traffic is collected in a way that it is possible to disaggregate the transport of food products from other consumer goods. It is also possible to differentiate between long-distance freight traffic, short-distance/local freight traffic and freight traffic from abroad. In Austria, the share of food freight is about 10.4% of total annual freight volume measured in tons/kilometre. The food freight volume increased by about 10% since the mid-1980s - approximately the same rate as total freight in the same period. However, growth after 1995 when Austria joined the EU is estimated to be considerably higher. A German study has estimated that average food miles per capita since the 1970s have risen by approximately 70% while per capita food consumption levels have remained unchanged (Mildner and Böge, 1996 in Payer 2000). In Sweden, road goods transport of food by lorries increased from 3 953 million to 4 684 million ton-km between 1985-1995. Mean haulage distance and mean load weight for food transport has also increased.

The modal split of food freight across the case study countries shows a clear dominance of road (truck) traffic. In Sweden and Poland, 89% and 80% of all land transport of food and agricultural products was by truck. In Austria, truck transport constitutes 75% of total food transport (in tons/km) (Table 12). In Austria long distances also prevail over short distances on average. Domestic long-distance freight traffic together with transit traffic account for approximately 70% of total food related transport performance, compared to 20% for short distances. Average distances are 50 kilometres for short distance transport and 230 kilometres for long distance. Domestic long-distance freight traffic shows the highest rate of growth. The share of food miles by air transportation appears to be low in Austria.[8] In comparison, although most

Table 12: Food miles in Austria, 1984 to 1995, annual freight traffic in million tons/km

	1984	1988	1993
traffic medium (modal split):			
road	1,984.3	2,006.0	2,039.3
rail	532.5	697.5	571.7
waterway	25.4	52.2	158.6
total	2,542.3	2,755.6	2,769.6
transport distances:			
domestic long-distance freight traffic	796.1	929.6	893.7
domestic short-distance freight traffic	542.1	527.1	576.8
import	240.7	248.8	252.7
export	136.2	200.1	172.2
transit	827.3	850.1	874.2
total	2,542.3	2,755.6	2,769.6

Sources: Payer 2000, own calculations based upon ÖSTAT Güterverkehrsstatistik, Payer et al. 1996, Rosinak & Partner 2000

food freight is also transported by road in the US, the share of food exports and imports carried by airplanes has grown. In 1980 ships carried 55% of US exports (by value) and airplanes 21 percent; by 1993 ships accounted for 36% of exports and airplanes for 29% with surface transport to Canada and

[8] In terms of absolute tonnage, freight transportation by air accounts for only 0.0002% of total freight traffic. Since the mid-90s freight export via the Vienna airport, by far the biggest airfreight destination in Austria, has remained constant (ÖSTAT in Payer 2000).

Mexico accounting for the rest. Air freight's share of imports grew from 12% to 21% between 1980 and 1993 (Eno transportation foundation 1994 in Kauffman and Chevrot 2000).

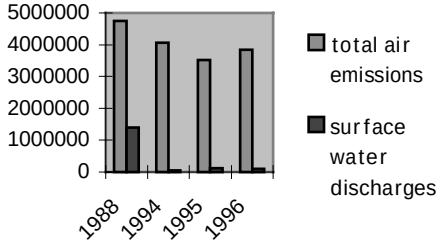
The environmental impacts of transportation patterns differ with the mode of transport. Airfreight is the most energy intensive, followed by trucks. The rapid growth of transport distances is closely connected with the general centralisation of production sites, the reduction of small stores in favour of big supermarkets, hypermarkets and shopping centres, and the rising internationalisation of nutrition habits. Changes to food conservation techniques (e.g. closed cooling chains), packaging systems, and an increasing demand for large storage plants also have implications for transportation options. Both the US and Swedish country studies, for example, note that the demand for frozen and chilled foods has increased the need for flexible and quality-controlled transportation (e.g. refrigerated trucks). In contrast, a higher percentage of unprocessed grains are transported by rail. Total environmental impacts from food transportation patterns will depend on the net effect of these trends and the potential for more efficient distribution patterns from centralised distribution and storage patterns. A large hypermarket can receive 50 different deliveries in one day, and a smaller shop around 10-15. With low price/cost margins in food production and marketing, firms have strong incentives to seek cost savings from new technology and energy efficiency. Transport to and between shops can be reduced considerably if different suppliers co-ordinate and use delivery vehicles more effectively (e.g. via "grouped traffic"). There are several examples in Sweden, Denmark and the UK where grouped traffic has been introduced with profitable results (Jedvall, 2000).

3.2.3 Air and water pollution

Both the US and Swedish country studies discuss the impact of the food processing industry on emissions to the air and water. Food processors cure, wash, fumigate, acidify, pasteurise, freeze, dehydrate, esterify, or apply other physical, chemical or mechanical techniques to preserve foods from microbes, enzymes, chemical deterioration or mechanical damage. In the US, the 1986 Emergency Planning and Community Right-to-Know Act requires that certain manufacturing facilities report releases of toxic chemicals into the environment. According to the Toxic Release Inventory (TRI) the food industry released 85 million pounds of pollutants in 1993. While this represents only 1.2% of total emissions, food processing is concentrated in a few states where the environmental impacts may be more intense. Chemicals released from the food processing industry that may have environmental impacts include ammonia, phosphoric acid, sulphuric acid, chlorine, hydrochloric acid, nitric acid, copper compounds and zinc compounds (Multimedia Environmental Compliance Guide for Food Processors, US EPA 1999, in Kauffman and Chevrot 2000). Two of the top 15 chemicals for total on- and off-site are OSHA carcinogens: atrazine and acetaldehyde. Atrazine is an herbicide used primarily by raw cane sugar producers and processors. Acetaldehyde is a common food flavouring added to milk products, baked goods, fruit juices, candy and soft drinks. It is used to produce vinegar and yeast and to preserve fruit and fish.

The two industrial groups with the largest release of toxic substances in the US were soybean oil mills and frozen and canned food processors, accounting for more than 50.7% of the on- and off-site releases and 56.5% of total production-related waste reported in the food and beverage sector (EPA, TRI, 1996 in Kauffman and Chevrot 2000). The food processing industry has made progress in reducing its emissions to the environment (Figure 11) and in on-site recycling of waste although TRI data also shows an increase in total production-related waste which suggests a potential for source reduction.

Figure 11 US - Air and water pollution from the food sector, 1988-1996



Source: Kauffman and Chevrot, 2000.

Wastewater at food processing facilities is generated during food preparation, processing and cleaning processes. Surface water discharges from food processing in the US increased from 6.5 million pounds in 1995 to nearly 9 million pounds in 1996 (an increase of 39%). Nitrate compounds mainly from meat processing facilities represented the largest discharges to surface water to 94% of total releases. Other regulated pollutants include biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids, oil and grease, total Kjedhal nitrogen, high or low pH, ammonia nitrogen, and phosphorous.

3.3 Measuring environmental impacts from household food consumption

The quantification of environmental impacts from household food consumption is a relatively undeveloped area of public policy research. A separate study was commissioned to review of some of the more important methodologies and to propose a set of indicators that could be used to more closely monitor environmental impact trends in this area[9]. This section presents the key conclusions from that study and proposes a subset of indicators that could be used to more closely monitor environmental impact trends in this area. Annex 2 provides the comparative analysis of the 8 different methodologies reviewed. Annex 3 provides the fuller list of indicators that could be developed in the future.

3.3.1 Methodologies

Several methodologies have been developed and applied to food consumption analysis that can help improve the assessment of environmental impacts from household food consumption. The ESU studies reviews eight methodologies for evaluating environmental impacts from household food consumption:

- Cumulative Energy Requirements Analysis (CERA)
- Input-Output Analysis (IOA)
- Hybrid Analysis (HA)
- Life Cycle Assessment (LCA)
- Ecological Footprint (EF)
- Material Intensity per Service Unit (MIPS) or Ecological Rucksack (ER)
- Material-Flux Analysis (MFA)
- Transport related methods

For each methodology the analysis introduces: the principal intent, procedure and technical terminology used; the scientific background and the scientific community and journals used for peer review and publication; the product life cycle stages examined and the emissions and resource uses covered in the inventory; the indicators used and aggregation principles adopted in each approach; and data requirements and availability. The analysis indicates the frequency of case studies using each methodology and provides an example from a case study to illustrate its use. Finally, the main strengths and weaknesses of the different methodologies are described, including technical restrictions, practical implementation and limits of the underlying assumptions. See Annex 2 for a full description of each methodology and an example of its use.

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9 *Methodologies for the Evaluation of Environmental Impacts from Consumption*, Niels Jungbluth, PhD and Rolf Frischknecht, PhD of ESU-Services, Ulster, Switzerland, (Paper for the OECD Environment Directorate, Programme on Sustainable Consumption, October 2000).

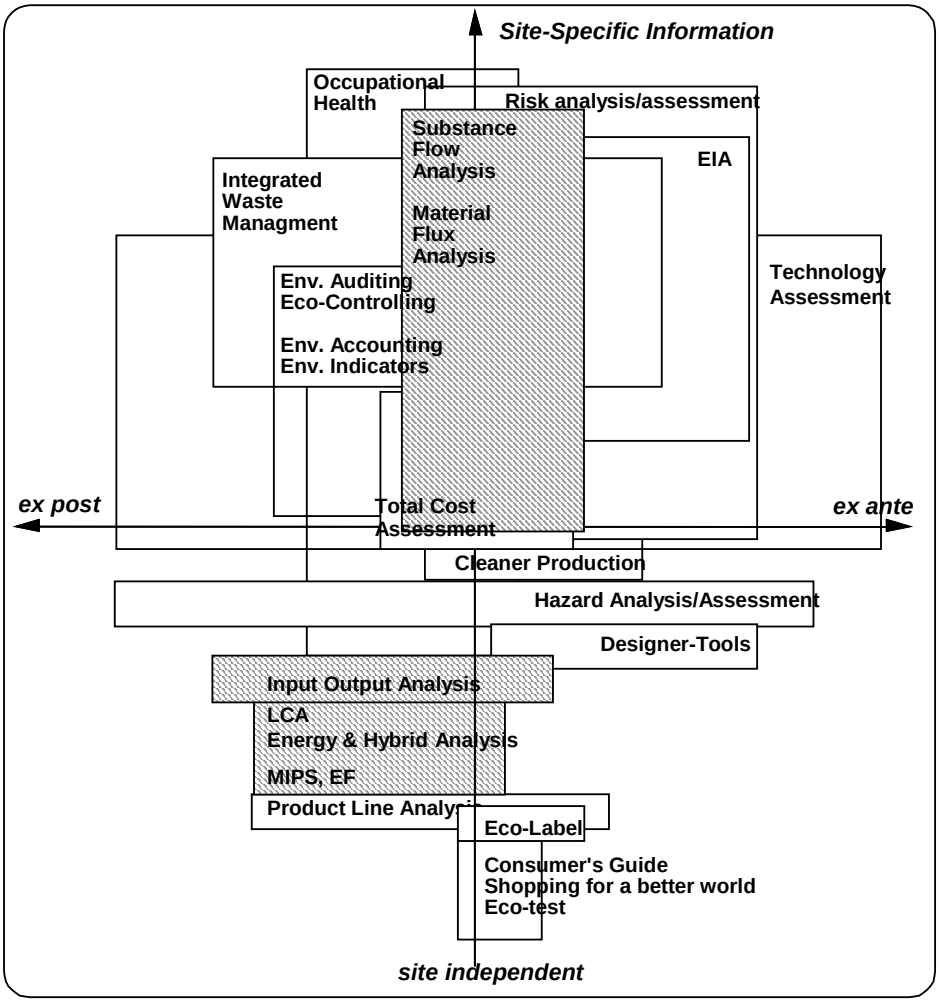
Comparison of the different methodologies

Different tools for environmental management can be positioned with respect to their treatment of the important dimensions of space and time. Figure 12 shows an overview for different environmental management tools in the time-space area (Hofstetter 1998). The methodologies discussed cover different types of decisions. Material-flux (or material flow) analysis, for example, generates site-specific information for current and past situations. LCA and cumulative energy requirements analysis focus on product-specific information normally with data from the past. Not every methodology fits every problem: it is important to choose the appropriate tool for answering the questions identified.

Most of the methodologies described in Annex 2 are descriptive. They are not suited to forecasting the future or to analysing historical trends. The main differences between them are related to their site- or product-specificity or the environmental indicators and databases used.

In Table 13 the levels of decision-making at which different actors can take environmentally relevant actions are shown. Jungbluth and Frischknecht (2000) assume that consumers have the widest range of possibilities open to them to behave in an environmentally sound manner. A consumer can decide to shift money from one field of need (e.g. mobility, nourishment) to another. This might be environmentally relevant if one spends, for example, less on travelling, but more on eating in an organic-food restaurant. Within the need field of "nourishment" one can decide, for example, to eat mainly in fast-food restaurants or to consume only vegetarian food. Closely related to this are decisions between different product groups (vegetables, meat). In one product group (e.g. meat), one can choose to buy more pork or more beef. Decisions within one product category (e.g. cabbage) with different products (e.g. cauliflower, red cabbage, etc.) are very similar. Often the choices among variants of a product (e.g. organic or conventionally grown carrots) are more relevant for consumers. If the decision has been made for one product, there is still a possibly relevant choice, e.g. for a certain packaging. The consumer can also decide about the processing (e.g. cooling, cooking) of a product in the household. All levels of decision-making are relevant for the overall environmental impacts of individual consumption patterns.

Figure12. The location of environmental management methods in the time-space area. "Time" addresses the descriptive or predictive power of the tools and "space" addresses the spatial differentiation within the tool. Methodologies discussed in this report are shaded . All tools in the lower half of the figure are site-independent (ordinal scale). EIA = Environmental Impact Assessment (modified from Hofstetter 1998:25)



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Jungbluth and Frischknecht argue that other actors in the food chain do not have such a variety of environmentally relevant decisions. They are more dependent on the market and on decisions of co-operating actors. Decisions about processing, pre-products or additives are mainly relevant for the producing or processing actors (food industry). An ice-cream producer can decide for example about the use of certain raw materials, or to reduce the amount of energy used in the factory, but he or she normally does not consider producing beer instead of ice cream due to environmental reasons.

Table 13. Levels of environmental decision-making for different actors in the food chain and appropriate methodology for an analysis of these decisions (JUNGBLUTH *et al.* 2000).

Farmer	Food-industry	Trader	Consumer	Waste management	Level of decision making	Example	Evaluation methodology
					9 All need fields	Mobility, nourishment, ...	IOA, EF, HA, MIPS, MFA
					8 One need field	Home cooking, restaurant, …	MFA, MIPS, IOA, HA, EF
					7 Product groups	Vegetables, meat, ...	HA, MFA, EF, LCA
					6 One product group	Beef, pork, poultry, …	CERA, LCA, HA, MFA
					5 Product category	Cabbage, salad, ...	LCA, CERA, HA, MFA
					4 Variants of a product	Organic, conventional	LCA, CERA, HA, MFA
					3 One product	Types of packaging, ...	LCA, WASD, CERA, MFA
					2 Processing	Cooking, cooling, …	LCA, CERA, MFA
					1 Intermediate product & additives	Cleaning agents, …	LCA, CERA, MFA

The actor's influence on environmental impacts:

	Directly: The actor can reduce environmental impacts directly.
	Indirectly: The actor can reduce environmental impacts in co-operation with other actors in the life cycle.

The different levels of decision-making introduced in Table 13 can be supported with different methodologies. The levels (1– 4) of decision-making are often investigated with life cycle assessment (e.g. decisions about which intermediate products are to be used in processing). At the top, the hierarchy of decisions made by actors is taken into account. Decisions about different need fields entail more serious changes than decisions about different variants of a product. Today, energy or input-output analysis is used in order to support this type of environmental decision-making. The last column of Table 13 shows a list of methods that can be used to investigate consumer decision in these levels of decision-making. In order to choose the appropriate methodology for a given problem or question it is necessary to know the main attributes of each methodology. Table 14 summarises the different methodologies described and the level of decision-making that can be addressed with each different methodology.

Table 14 Summary of the criteria for evaluating different methods for investigating the environmental impacts of food consumption and level of decision-making addressed by the methods (product = product and/or service).

Methodology	Principle	Indicators and weighting principle	Data availability	Scientific background	Strength, Purpose, Level of decision making	Weaknesses
Cumulative energy requirements analysis (CERA), Process-Chain Analysis	Energy use summed up for all stages in the life cycle of a product.	Aggregation (with different methods) of the primary energy content of energy resources used for the production of a product (e.g. MJ/kg).	In general good.	Long tradition with publications in different journals, like Energy Policy, and published guidelines for the methodology.	Easy to apply; single indicator and good databases available. Analytical tool that can be used for information of consumers (Level 1-6)	Energy is not necessarily a good indicator for all types of environmental impacts caused in the life cycle (e.g. agriculture outputs).
Input-Output Analysis (IOA)	Economic flows among different sectors of economy are used to calculate energy (or environmental) intensities for goods from single sectors.	Primary energy content of energy resources used (pollutants emitted) in a sector per economic value created (energy or environmental intensity, e.g. MJ/CHF).	Good in some countries (e.g. USA, Germany, The Netherlands), poor in others (e.g. Switzerland).	Developed as a tool for economic research. Publications in different journals.	Easy to apply for the analysis of a full range of household activities. (Level 8-9)	Not specific for different environmental impacts and not suited for decisions about single products because of high level of aggregation.
Hybrid-Analysis	Combination of input-output and process-chain analysis to calculate the energy intensity of consumed products.	Primary energy content of energy resources used per household expenditure for a certain product (energy intensity, e.g. MJ/CHF).	High initial effort in a country. Good database for the Netherlands.	Developed mainly in the Netherlands.	Easy to apply for the analysis of a range of products. (Level 4-9).	High initial effort in a country for input-output database.
Life-Cycle Assessment (LCA)	Investigation of environmental impacts over all stages in the life cycle of a product.	Different methods for characterisation of elementary flows to impact or damage categories based on their effect or damage potential (e.g. global warming potential per kg) or on political targets.	Good background data for energy processes, different case studies, but not a full survey of all food products.	Different journals, LCA group within SETAC, LCA network Food, ISO-standard.	Structured and flexible approach for inventory and weighting principles. Detailed analysis of environmental impacts (Level 1-7)	High data demand for single products. Some methodological problems while accounting for the impacts of agriculture.
Ecological Footprint (EF)	Investigation of actual and theoretical land uses over the full life cycle of certain activities.	Calculation of the theoretical area necessary to deliver the demanded goods and services with data for direct land use and indirect assessment of the area for absorbing CO_2 emission from fossil fuel use.	Case studies mainly not specific for food consumption. Harmonized data on the level of nations.	Email discussion list. Articles in Ecological Economics.	Easy to communicate as a proxy indicator for sustainability. (Level 7-9)	Fixed weighting scheme that disregards the emissions of some toxic substances that are assumed to be unsustainable.

Material-Flux Analysis (MFA)	Assessment of material flows or energy uses due to certain activities in a defined system.	Analysis for indicator elements or energy use, regarded as environmentally relevant, and aggregation of chemical substances with the content of the indicator element (e.g. total C mass from CO_2, CH_4, etc.).	Data from different statistics and information about production processes. Data availability depends on the case study investigated. No specific background data for MFA.	Several working groups in e.g. Germany, Austria, Switzerland.	Easy to communicate, good for a system analysis and flexible in terms of weighting environmental problems. (Different levels between 1 and 9 are addressed in case studies).	Equivalence of different emissions with unequal environmental impacts. No clear procedure to choose indicator elements and to assess their environmental relevance.
WASP/WASD and other transport-related methodologies	Assessment of transported distances over some or all stages of the life cycle of a product.	All modes of transport are aggregated. Indicator is the total distance of freight movement in kilometres or indication of tonne-kilometres.	No good public databases for different transport steps. Information relatively easy to obtain from producers.	No standardised methodology. Mainly developed in Germany and Sweden. Different case studies for food products.	Easy to communicate. Yardstick for the analysis of transport related impacts due to globalisation. (Level 3).	Transport trends do not provide a full picture for the environmental impacts caused. Different modes of transportation not distinguished.
Material Intensity per Service Unit (MIPS) or Ecological Rucksack (ER)	Investigation of materials moved over all stages in the life cycle of a product.	Aggregated mass flows. All masses are added non-weighted in 5 categories (e.g. kg/kg product).	Case studies mainly from Germany. No good public databases.	Mainly developed by the Wuppertal-Institute in Germany.	Useful as a proxy indicator to communicate the necessity for a change of consumption patterns and to monitor progress in dematerialization. Single indicator for mass and energy (Level 8-9)	Fixed weighting scheme that does not reflect the environmental impacts caused by the masses moved. Considers only inputs, but no outputs to the environment.

Key case study results for the environmental impacts of food consumption

Jungbluth and Frischknecht reviewed the use of the different methodologies in the environmental impact case study literature. The following section summarises the key results from that review. This summary also serves as background for the discussion in the next section of indicators to monitor the development of environmental impacts from food consumption. The review of different methodologies for evaluating the environmental impacts of household consumption patterns shows that every methodology has advantages and disadvantages. No single methodology provides answers to every kind of question.

The selection of an appropriate methodology depends on the question to be answered, the data available and the decision-maker to be addressed. Some methods have been developed in order to communicate the necessity of sustainable development while other methods address consumer and producer questions about single products. The databases available for an ecological assessment vary from country to country. In the USA, for example, it is relatively easy to apply an IOA while in Switzerland it is easier to use LCA for certain questions.

Case studies of the application of different methodologies in the field of household food consumption help to identify the key factors for the determination of environmental impacts. They show that there is no single factor that determines the impacts, but that different stages in the life cycle and certain changes of consumption patterns have to be taken into account. They highlight the following points of major interest when determining the environmental impacts of food consumption patterns:

- Food consumption is an important field for the environmental impacts caused by total household consumption and accounts for approximately 15% to 20% of the environmental impacts in OECD countries.
- Different types of environmental impacts must be considered (depletion of energy resources, land use, ecotoxicity of pesticides, eutrophication) over the full life cycle.
- Intensive agricultural production techniques (e.g. greenhouse production) lead to higher environmental impacts than less intensive production methods, as e.g. organic agriculture. However, discussion about best practice is still evolving. JUNGBLUTH (2000) shows that no clear general preference may be given when comparing the environmental impacts of integrated and organic production. Parameters such as functional unit, fertiliser use, or the valuation of pesticide use influence the results of a comparison of individual studies.
- The change towards more meat consumption, conserved and pre-prepared products leads to increased environmental impacts.
- Globalisation and diversification of consumption patterns lead to a rise in emissions from food transports.
- Consumer behaviour (type of diet, waste produced, use of cars and energy consuming household appliances, etc.) influences significantly overall environmental impacts due to food consumption.

3.3.2 Indicators for Monitoring Environmentally Relevant Trends of Food Consumption

In 1999 the OECD Environment Directorate proposed a preliminary set of indicators for monitoring the environmental impacts of household consumption patterns (OECD, 1999). This set included two indicators related to household food consumption to measure food consumption intensities and patterns:

1. by type of food (fish, meat, etc.) in kg per capita,; and
2. by growing method and level of process (share of processed food, share of organically grown produce over total agricultural produce consumed) as a percentage of total food consumption.

Jungbluth and Frischknecht suggest a refinement of the two OECD indicators and propose an additional twelve. The indicators proposed should help to quantify and compare the environmental impacts from food consumption patterns in different countries over different years. They are organised in five groups: production methods, transportation, purchasing, consumption levels, and household behaviour. An additional group of non-quantifiable but key issues are also identified. In identifying the 14 main indicators, emphasis was given to the following criteria:

- policy relevance for monitoring and priority setting,
- analytical soundness of the indicator with regard to the environmental impacts, and
- measurability and proposal for appropriate methods to quantify the environmental impacts (roughly ordered according to their appropriateness and the data availability).

Annex 3 provides the full list of proposed indicators. Given current data availability and the importance of the measured impact Jungbluth and Frischknecht propose that seven out of the fourteen indicators be given priority:

1. Share and per capita availability of products from e.g. organic, integrated, conventional and greenhouse production
2. Share and per capita consumption of food products with different degrees of processing (fresh, chilled, conserved, deep-frozen, pre-prepared, ready made, self-service and restaurant)

6. Per capita average distance and mode of transportation for domestic food transports
7. Per capita average distance and mode of transportation for imported food transports
9. Types of food distribution (direct on farm, market, small shop, supermarket, fast-food, restaurants, etc.)
10. Per capita food availability (kg or MJ nutrition value per head) and share of different product categories (meat, vegetables, grains, fats, beverages, etc.) in food consumption
14. Distribution and energy use of household appliances for food storage and preparation.

These indicators cover important environmental impacts from household food consumption and it is possible to calculate them using available statistical databases. Some of the indicators proposed are also linked to other fields of household consumption or might intersect with indicator sets for sustainable development in other economic sectors. The indicator for eco-labelling, for example, might also be dealt with in indicator sets for agricultural production practice. Or the share of different modes of transportation to bring food products to the household might also be covered by an indicator describing the general impacts of private mobility. As a result, the indicators should be cross-checked with indicators from other

fields of household consumption or for industries to ensure that there is no double counting of the same effects.

The direct quantitative measurement of the environmental impacts due to household consumption patterns is not easy. Different methods can be used to estimate generic indicators. As a result, it remains difficult to compare results for different countries in detail, as this would require original calculations of environmental impacts for each country. Today, it is also difficult to compare with precision impacts over a time period, because this requires that all underlying calculations of environmental impact be made for different years separately in order to also monitor improvements (e.g. production methods). Additional research work is required.

Further research is also needed on the indicators and methods that could be used by OECD decision-makers in order to generate generic quantitative factors that can be used to calculate the environmental impacts based on statistical data for different countries. Proposals for suitable methodologies are given for each indicator in Annex 3.

The development of generic factors that can be multiplied with statistical data would help to compare the environmental impacts or energy uses of consumption patterns quantitatively. For example, in a first step the energy use linked to the average consumption of 1kg of vegetables, meat, or milk products, etc. is estimated with a hybrid analysis. These energy requirements could be multiplied with statistical data for the per head availability of food products from these groups in order to determine and compare the average energy use due to food consumption for different OECD countries.

For the moment, calculations for energy use with CERA, IOA, HA or LCA would be the easiest approach for calculating generic factors for the indicators proposed. Later, using other methodologies that quantify the environmental impacts more accurately, for instance LCA, it would be possible to extend these indicators.

4. POLICIES TO PROMOTE SUSTAINABLE HOUSEHOLD FOOD CONSUMPTION

The national case studies on household food consumption identified links between public policy and planning and household food consumption patterns and measures policy makers could take to help households reduce environmental pressures in the food cycle. The discussion in this section summarises those findings.

Section 4.1 suggests broad policy objectives and framework to promote sustainable household food consumption. Section 4.2 looks at general policy orientations related to food and environment in the case study countries. It shows that although there are no "sustainable food consumption" policies, growing concern over environmental health and food security are forging stronger links between traditional nutrition and consumer safety policy and environmental policy. Section 4.3 examines specific policy measures to reduce the direct environmental impacts from household food consumption patterns. The discussion shows that some policies exist to deal with general household energy consumption and waste generation patterns, including sometimes specific measures relevant to household food activities. On the other hand, there are few examples of policies to deal specifically with food transportation or the greenhouse gas effects of food consumption patterns. The discussion also makes clear that household food consumption patterns should not be treated in isolation but rather addressed as an important part of a set of daily household routines that influence and reinforce one another. More systematic analysis of the environmental and cost effectiveness of policy instruments to reduce the environmental impacts of food consumption is needed to refine this discussion. Section 4.4 discusses policies and information to support informed consumer choice as one way of influencing upstream impacts in the food production and processing sectors. Section 4.5 concludes this report and identifies issues where additional research is needed to better understand the net environmental impact of evolving food consumption trends.

4.1 Policy objectives and framework

The policy implications of current trends in household food consumption and their environmental impacts can be explored with two broad objectives in mind. The first takes current household food consumption patterns as given. This approach recognises that many household consumption patterns are unlikely to change in the short-term and so focuses on practical measures to work with existing patterns to reduce related environmental impacts. These would include measures targeted directly to consumers (i.e. to increase energy efficiency, reduce packaging and food waste, or develop options for food transportation). They would also include measures to promote technology, product and service innovations in the intermediate food industry (processing, service, retail) and primary production sectors to maximise resource efficiency and reduce waste and releases to the environment.

The second objective recognises that consumption patterns can and do shift over time, and seeks ways through which households could be encouraged to make changes in their purchases and behaviour towards less environmentally damaging patterns. This approach recognises the medium- to long-term need to change consumption patterns for certain goods and services in order to respond to environmental pressures related to absolute increases in consumer demand. Measures would include longer-term strategies to shape the economic and socio-cultural factors (education, media influence, social parameters), policy, technology, and infrastructure that contribute to broader, and perhaps more deeply rooted, attitudes

driving household food consumption. The EU-funded research project SUSHOUSE (Strategies Towards the Sustainable Household), for example, is developing scenarios for sustainable shopping, cooking and eating for 2050 based on a factor 20 reduction in associated environmental impacts. The project assesses the scenarios for economic credibility, environmental effectiveness and consumer acceptance, and identifies strategies and policy for moving households toward those scenarios.[10] These kind of initiatives can be useful for setting long-term policy objectives.

The distinction between short-term and medium- to long-term objectives makes it possible to identify a variety of responses by a range of actors (consumers, governments, private sector, academia/research) and to better capture some of the dynamics behind the development of household consumption patterns. In the area of food consumption, for example, likely structural changes over the next twenty years in the agro-food sector, including further vertical integration and continuing concentration in the retail sector, will increase the importance and influence of the food processing, distribution and service sectors in the future. Similarly, growing household demand for a safe food supply offering both variety and convenience suggests both potential obstacles and opportunities for reducing the environmental impact from household food consumption. Ensuring that these trends develop without adding additional environmental stress will mean working simultaneously to improve technology to better address energy use, emissions from transport, and the generation of packaging waste, while stimulating households to make environmentally aware decisions through price signals, information, and a wider availability of environmentally preferable products on store shelves or Internet shopping sites.

Some areas of household environmental impact from food consumption patterns are best addressed as part of broader strategy encompassing important household routines (e.g. travel, energy consumption, waste generation, shopping patterns). Results from OECD work on *information and consumer decision-making* show that is important to consider the full range of consumer behaviours and household decision situations when working with households to reduce their environmental impacts (OECD, 2001a forthcoming). This analysis shows that consumers often make internal trade-offs between different types of behaviour in an attempt to balance what they perceive as environmentally unfriendly behaviour in one area with pro-environmental behaviour in another. No consumer is consistently "green" across all categories of behaviour and probably most consumers act at least from time to time with the environment in mind. At the same time, experts agree that consumers are often "stuck on an old environmental agenda" or confused about which environmental actions really matter. They need clear information and guidance on which of their own actions make the most difference. It is important to understand these dynamics because they influence consumer perceptions of the feasibility and importance of making certain pro-environmental decisions and suggest different strategies for government measures to influence those decisions, including those related to food purchases, preservation, preparation and disposal.

4.2 General policy orientations related to food and the environment

It is not surprising that none of the countries profiled in the case studies series had a "sustainable food consumption" policy or strategy. Food policy in most OECD countries naturally focuses on ensuring adequate access to a food supply that is nutritious, safe and of high quality. And while food nutrition guidelines have slowly moved from a quantitative supply focus to guidance on basic food groups that are more easily understood by consumers, they generally do not include qualitative aspects of the food supply or environmental considerations linked with certain food choices.

Nevertheless changes are happening on the margin of food policy -- primarily through the rising prominence of "environmental health" issues -- that provide a stronger link to sustainable consumption objectives. For example, the Austrian Federal Ministry of Forestry and Agricultural Affairs published for the first time a *national food report*, which included a complete chapter upon the dynamics of the domestic

[10] For more information contact ken.green@umist.ac.uk.

market of organically produced food. The report goes beyond the strong medical orientation of traditional nutrition reports to monitor structural changes along the entire food chain after Austria's accession to the EU in 1995 (Federal Ministry of Forestry and Agricultural Affairs, 1997 in Payer 2000). Similarly, the first nutrition report for the federal state of Vienna includes detailed statements on the quality of organically produced food products, the contamination of drinking water, and consumer concern about genetically modified food products (Elmadfa et al 1994 in Payer 2000). On a project level, the project data bank of the Forum Gesundes Österreich (FGÖ) - the biggest governmental fund in Austria for public-private health promotion activities on both local and national levels - contains a list of about 300 funded activities that have been started since 1996. These activities most frequently focus on exercise and nutrition, followed by psychological health and medical welfare. But of the 200 projects dedicated to nutrition issues, nearly 30 different projects were established in the context of both nutrition and the environment.

Also in Austria, a closer connection between sustainable patterns of food consumption may lie in the National Environmental Health Action Plan (NEHAP) published in 1999. The Plan follows a 1994 commitment by European Ministers of environmental and health affairs who acknowledged that sustainable development would requires shifts in consumer behaviour. The Federal Ministry of Environment, Youth and Family Affairs, the Federal Ministry of Labour, Health and Social Affairs, and the Federal Ministry of Women Affairs and Consumer Protection published the Austrian NEHAP as a common strategy paper, aimed at integrating overlapping policy fields of environment and health. The Austrian NEHAP identifies 11 priority thematic fields at least four of which (food, water, traffic and settlement) are linked to sustainable food consumption. However, with the exception of the field of food quality and safety the Austrian action plan does not offer any proposals related directly to food consumption.

Also in the context of EU integration, a 1998 government decision in Sweden called upon 22 Swedish governmental authorities to integrate environmental considerations and "green housekeeping" in their activities. The Swedish Consumer Agency set forth a number of sector goals, based on the recognition that the consumer sector will in one way or another influence nearly all national environmental quality goals. Particular focus was given to consumer choice of foods and other consumer products, housing patterns and transport. Based on a long-run vision – where the consumer will not have to choose between "good" or "bad" products, because only "good" products will be available – the consumer is called upon in the short-run to force these developments through information and product choice. With this as its basis, the Swedish Consumer Agency proposed the following sector goals:

- Goods and services shall - except being functional and safe - be good from an environmental point of view and provide correct and relevant information;
- Systems for disposal of end-of-life products should be easy for households to use; and
- Consumers will be stimulated to live and act in an environmentally sound way.

A set of indicators were proposed to evaluate progress in reducing environmental impacts from the consumer sector, several of which are relevant to food consumption patterns (See Box 1).

Swedish national objectives and strategies for nutrition (1999-2004) have also been elaborated to provide a tool for all Swedish authorities promoting better food habits. The goals indicate the direction and responsibilities of different public authorities working on nutrition work, but also function as guidance for regional and local actors. The objectives and strategies cover 4 areas: (i) education, (ii) support to local and regional work, (iii) consumer support and participation, and (iv) large-scale kitchens.

In Poland, the National Health Programme, developed in 1990 and revised for the 1996-2005 period, contains several operational goals, two of which are directly related to food and the environment. Many actors representing different sectors contribute to the Programme. Operational goal 2 is the improvement in nutrition patterns and an enhancement of food quality. Operational goal 8 seeks a

Box 1 Sweden - Indicators for evaluating environmental impacts from consumer behaviour

- The market for goods that are environmentally labelled;
- The number of environmentally labelled types per product group;
- The use of electricity, heat and water;
- The amount of packaging collected in relation to the total amount sold;
- The access for consumers to KRAV labelled products for foods (organic)
- The consumption of different types of meat (e.g. meat from grazing animals that keep the landscape open)
- The consumption of animal or vegetable protein (a measure of an eventual development towards reduced meat consumption and consequently less energy use and less eutrophication)

Source: Jedvall, 2000.

reduction in public exposure to harmful elements in the living, working and educational environment. In addition, in July 1999 the Council of Ministers accepted a document on "A coherent structural policy for the development of rural areas and agriculture" that outlines activities to reduce the harmful impact of agriculture on the environment and to expand the use of environmentally friendly farming practices, particularly organic farming. In April 2000 a draft legislative act was submitted to the Polish Parliament to provide for the provision of special payments for farmers converting to organic farming and to regulate, in harmonisation with EU regulations, the use of labelling for organic products.

Supply-side policies in the food production sector and household food consumption

A wide range of government policies, both agricultural and non-agricultural, exert a profound influence on the size, location, output mix and environmental performance of the agricultural sector, especially in those OECD countries that provide high levels of support linked to inputs and outputs (OECD, 1999b). It was beyond the scope of this project to explore those policies. However, a few examples of such policies were provided in the national case studies to draw attention to the direct or indirect links between some policies and food prices and choices at the consumer level.

In the US, for example, Federal and State price support programs for basic commodities (wheat, rice, feed grains, oilseeds, milk, peanuts, and sugar) are intended to stabilise and/or support prices for these commodities and, in some cases, ensure incomes for the producers. There are also programs that support stable markets for producers of milk, fruits, vegetables, and some speciality crops. Several commodities are also covered by federally authorised research and promotion agreements (see Section 4.4 on Food Advertising) (Ralston, 1999 in Kauffman and Chevrot 2000). Because such programs isolate both producers and consumers from world prices they distort markets and sometimes hide the environmental costs of production and indirectly consumer decisions. The 1996 Farm Bill and other policy modifications have eliminated or begun to phase out many program components such as price-dependent income support payments for wheat, rice, and feed grains, and limited price supports for these crops as well as for sugar and peanuts. These developments suggest that policy, even though not motivated by environmental objectives, is moving in the right direction, although high levels of support still exist, in the US and many other OECD countries. The Austrian study points to the effect of EC regulation No. 2092/91 which provides the legal basis for providing premiums to organic farming, enabling both an increase in the supply of organic goods and a relative decrease in the high price paid by households for some organic foods.

The US study identifies several market-related instruments and food support programs that are related to food consumption patterns. The food assistance programs of the USDA take a variety of forms, providing different types of food benefits to various target recipients. Three programs account for 85% of

the total ($33.6 billion) spent on food assistance in 1998: the Food Stamp Program, the National School Lunch Program, and the Nutrition Program for Women, Infants, and Children (WIC). The environmental impact of these programs have not been evaluated but the US national case study notes some links to food choices that have an environmental impact--e.g. meats, poultry, and sugar. For example, the USDA is an advocate for US agriculture and hence must balance its responsibility to provide healthy nutritious assistance meals with its responsibility to support and promote US agricultural production. To this end, the School Lunch program includes support to farmers by buying surplus dairy and meat products. The USDA maintains that there are no "good" or "bad" foods, instead stressing the importance of balanced diets. So while the potential is present in these programs to influence reductions in food consumption of commodities that have higher environmental impacts (say, beef consumption), it is unlikely that the agency would be responsive to lowering market levels of major agricultural commodities. On the other hand, the agency has explored the potential for making dietary changes--such as in food preparation (baked vs. fried foods, for example) while keeping the commodity groups at their baseline market level. The National School Lunch Program serves lunches to over 25 million children per day and thus represents a ready tool to improve dietary quality (Gundersen, 1998 in Kauffman and Chevrot 2000) and influence longer-term eating patterns.

The US and Swedish country studies briefly discuss other areas of government regulation that can influence consumer food decisions. Appendix 1 presents a compilation of US regulations that affect the food sector. In many cases these regulations have a direct or indirect effect on consumer behaviour but the size of the effect is limited or difficult to estimate.

4.3 Policy measures to reduce direct impacts from household food consumption patterns

Improving energy efficiency and conservation for food conservation and preparation

Since the 1970s, energy policy in many OECD countries has included measures to reduce household energy demand, particularly for space and water heating -- the two most important categories of household energy use. Higher energy prices, stronger building codes, subsidies for conversion from oil to more sustainable (or cleaner) energy sources, and other programmes to encourage home insulation have significantly reduced the energy intensity[11] of household space and water heating. In contrast, governments have done comparatively less to reduce household electricity consumption, which has continued to grow with GDP due largely to greater household ownership of appliances, including food related appliances (refrigerators, freezers, dishwashers, microwaves and various other kitchen appliances).

Manufacturers have made tremendous gains in appliance efficiency over the last several decades. These gains have been stimulated in part by higher energy prices. However, governments have also promoted efficiency improvements through the promulgation of *efficiency standards* for household appliances. Standards for household appliances have increased product quality across the board and eliminated from the market those products with the poorest performance. As a result, consumers today have a superior range of products to choose from than just a decade ago. Refrigerator standards have been particularly successful because they not only substantially reduced energy use for this major household electricity user but did so without a significant increase in product price. The average North American refrigerator, for example, used 1,800 kilowatt hours (kwh) per year in 1975 but now uses 75% less energy without a decrease in performance or significant price rise.

In the US, 1987 amendments to the Energy Policy and Conservation Act established national efficiency standards for different household appliances, including refrigerators and ovens. The national standards were readily accepted by industry because they seemed preferable to dealing with divergent state regulations (Brower and Leon, 1999). Different studies in the US have estimated the economic costs and

[11] Energy intensity refers to the amount of electricity needed for a particular end-use, such as space and water heating or running household appliances.

benefits of household appliance standards, including one by the American Council for an Energy-Efficient Economy which estimated that although the standards would cost consumers $59 billion in higher appliance and equipment prices, they would save consumers and business about $190 billion on their energy bills over the forty-year period between 1990 and 2030 (Geller in Brower and Leon, 1999). A 1996 Department of Energy study estimated that the various appliance standards would reduce emissions by more than 50 millions tons of CO_2 and 750 thousand tons of nitrogen oxide through 2000 (Brower and Leon, 1999). The European Commission adopted energy use standards for refrigerators and freezers in 1994. There is still significant potential for efficiency gains for many household appliances, and some key household food-related appliances (ranges, ovens, stovetops) are not subject to minimum efficiency standards. This suggests a continuing and extended role for government minimum performance standards.

In the future there could also be an expanded role for *voluntary agreements* with appliance manufacturers to improve energy efficiency. New voluntary, or negotiated, agreements are being set up in some OECD countries for other consumer appliances, such as clothes washers and consumer electronics (IEA, 2000a). The voluntary agreement on clothes washers as part of the EU's SAVE agreement succeeded in phasing out the least efficient washers in 1994 (OECD, 2001).

A second important area of government intervention to promote household energy efficiency has been *energy labels* on household appliances: 37 countries in the world currently use energy-efficiency labels and standards. Energy efficiency labels provide consumers with a relatively simple guide to the comparative energy efficiency of a product. In the EU, energy labelling is now mandatory for refrigerators, freezers and dishwashers and efforts are currently underway to develop a similar system for stoves. In the United States, energy labels now appear on new refrigerators and freezers. Poland has a voluntary label for refrigerators and freezers.

Labelling has stimulated manufacturers to improve the design and formulation of their products and can influence consumer decision-making. The sales-weighted annual average energy-efficiency index of 'cold appliances' (refrigerators and freezers) in the EU, for instance, improved by 4.5% from 1994 to 1996 during the EU's cold appliance labelling programme (IEA, 2000a). However, more information is needed on consumer awareness of energy labels and their importance in consumer decision-making, particularly in relation to other purchasing criteria (e.g. high up-front costs versus long-term, dispersed savings, etc.). Appliance retailers could play an important role in better informing consumers about the comparative performance of different appliances because consumers are typically willing to invest some time in gathering information for high budget purchases. However, retailers and shop personnel often have other concerns and are often reluctant to volunteer "environmental" information unless requested by the consumer (OECD, 2001a forthcoming). Thus, while governments can provide concrete technical and other support to help retailers become more effective at providing environmental information continued pressure is needed to boost consumer demand for energy-efficient appliances.

In some countries, governments have combined efficiency standards and labelling with *financial incentives* to consumers to purchase higher efficiency models. In the Netherlands, for example, the 1990 Energy Saving Memorandum allowed energy supply companies to levy a surcharge on energy bills to finance their activities in the context of the Environmental Action Plan, including information campaigns and subsidies to bring the sale of energy-efficient refrigerators to 1.3 million by 2000 (Noorman and Uiterkamp, 1998). And since 1994, under the Scheme for Environmentally Friendly and Energy-Efficient Refrigerators, energy companies have given consumers a Dfl 50 discount on any new, energy-efficient, ozone-friendly refrigerator or freezer if customers return their old models to an official collection point that guarantees the safe removal of CFCs (Noorman and Uiterkamp, 1998). The US Department of Energy and some private utilities fund programs to refund part of the money consumers spend on energy-efficient refrigerators (http://www.epa.gov/energystar).

The case studies also note the potential for *public information campaigns* to improve household understanding and awareness of their energy consumption patterns. Technical information to households on food storage and preparation, efficient use of electric appliances and waste disposal are all areas where

public information campaigns can help households reduce their environmental impacts. All four case studies noted consumer misperceptions of food conservation information (e.g. "sell by dates"), which could lead to unnecessary food waste, and the declining or variable food preparation skills that lead to large variations in energy use for the same meal (Poland, US[12]) and an increasing reliance on pre-prepared and packaged foods (all countries). These are areas where "useful tips" can decrease energy consumption and waste generation while saving the consumer money. Greater use of television, radio and the interactive possibilities offered by the Internet may be more effective in reaching disinterested or uninformed consumers than traditional information dissemination via brochures or pamphlets. Primary and secondary schools can be another effective information channel – initiatives in other areas of household consumption (e.g. water conservation; waste recycling) have often shown that the information school-age children bring home can have a sometimes significant impact on household activities (OECD, 1999 and 1998).

In Sweden, the Swedish Environmental Protection Agency, the Swedish Food Administration and the Swedish Consumer Agency worked in co-operation to link food habits not only with nutrition, but also with the environment. This collaborative effort resulted in a cook-book called “Food with a sense for environment” (“Mat med känsla för miljö”), which argues that consumers can substantially reduce energy use in the food chain by making the right food choices. The cook-book provides facts and advice to support consumers’ food purchases. More generally, however, public food guidelines are narrowly conceived around nutritional requirements and compete with massive industry spending to advertise certain food products. Even so, the US study argues that even within the traditionally narrow conception of food guidelines health and environmental objectives can merge. That study notes the potential for promoting education and consumer awareness through nutrition policies that would reduce American consumer demands for sugar and fats in the diet, which in turn would have not only positive health benefits but also reduce both energy consumption and air pollution in upstream industries.

Reducing the Environmental Impacts from Food Transport

As noted in the earlier description of trends and environmental impacts of food transportation, it is usually difficult to distinguish household travel patterns related to food purchases from other travel purposes. Household often link a number of travel destinations together. As a result, household travel patterns must be addressed in a way that takes all household mobility needs into consideration.[13]

Reducing the environmental impact from personal travel in general will require measures to induce the use of new or improved motor vehicle technology, the use of renewable and/or less polluting fuels, reorienting and augmenting investment for public transport systems, downsizing vehicles and resource use, and re-examining incentives for private car use (e.g. company car policies, flexible working hours). But it will also require going beyond the current public vs. private transport debate which tends to focus on means of transport rather than transport system objectives. A new and promising approach of multi-modal mobility services offers a wide palette of transport options for "seamless" multi-modal trips that would reduce the need for personal car use. Such systems are already being successfully marketed in a number of OECD countries. In the longer-term, integrated land-use and transport planning should improve aim to increase household accessibility to jobs, shops and other facilities without the need to travel by car (OECD, 2001).

A second difficulty in determining policies to reduce the environmental impacts from the transportation of food for household consumption is that the net environmental trends related to some

12 Tests by the US Bureau of Standards have shown that some people use 50% more energy than others do to cook the same meal (Kauffman and Chevrot, 2000).

13. See a second case study on *Household Tourism Travel Patterns*, OECD General Distribution Document EPOC/ENV/WPNEP(2001)14 and past work on Individual Travel Behaviour [http://www.oecd.org/env/consumption].

transportation patterns are not yet clear. For example the net impact of greater out-of-town location of food stores, and related consumer travel, will depend upon the ability of manufacturers and distributors to achieve existing potential to rationalise distribution systems and make significant transport efficiency gains. Similarly how developments in consumer food patterns, such as the expansion of e-commerce in the food sector, will affect overall transportation levels will depend on how consumers use these services: currently, household use of frozen food and food home food delivery services induce a demand for more packaging and refrigerated transportation, but don't necessarily diminish household transport because households still go to the store for other goods, including fresh produce. A clearer systems view of consumer goods transportation patterns, including cumulative "food miles" of major food products, is needed to determine strategic planning objectives.

Reducing Household Food-Related Waste Generation

OECD countries have several policy measures to reduce food-related waste including both measures that target food waste specifically and others that address household waste generation patterns in general. Many OECD countries use *economic instruments* including deposit-refund systems to promote the collection, reuse and recycling of beverage packaging (milk, mineral water, soft drinks, beer). These systems have been somewhat successful in reducing food-related household waste. However as the percentage of beverages packaged in plastic rise, the portion of beverages affected by deposit-refund systems is shrinking. In Austria for example, although the re-use quotas in the sectors of beer, bottled water, wine, non-alcoholic beverages and milk are quite high in comparison to other countries, the share of re-useable beverage packaging continues to decline. Economically feasible and effective policy solutions to the rising amount of plastic bottle waste have yet to be found.

Household food waste generation is more broadly affected by user charges for municipal waste collection and treatment. Charges or taxes on municipal waste have been highly effective in reducing waste generation or landfilling in many countries. In Denmark, for example, a tax on non-hazardous waste doubled the cost of waste dumping and increased the cost of incineration by 70%: between 1987 and 1993 the landfilling of household waste fell by 17% and recycling increased 77% for paper and cardboard and 50% for glass (OECD, 2001).

Waste charges typically are in the form of a flat tariff and represent only a minor part of household charges. As a result, a new generation of policies uses unit pricing to make the cost of waste management visible to households. Unit pricing policies use marginal price structures that penalise higher levels of waste generation by charging on the basis of the volume (e.g. "Pay-As-You-Throw" – PAYT) or weight of trash discarded instead of a flat tax or monthly fee. In the US, PAYT has been adopted in over 3900 communities. Although success rates vary, PAYT communities on average have reduced total waste generated by about 14-27%, while increasing recycling by about 32-59% (Miranda and LaPalme, 1997). Complementary programmes (curbside recycling, yard waste collection, bulky item pick-up, and education) can increase PAYT effects on source reduction and recycling rates, and discourage illegal dumping. PAYT programmes are also more equitable than flat-fee waste collection systems, where households that reduce their waste in effect subsidise those that do not. PAYT programmes are spreading globally and have been tried in several other countries, including Japan, Germany, Canada, Italy, the Netherlands, and China.

Regulatory measures related to the installation and operation of waste management facilities have also driven changes in waste management at the household level. Limitations on landfill capacity, such as the EC directive on the landfill of waste, has contributed to a growing trend to sort and/or pre-treat waste destined for landfill. This has translated into a wider penetration of curbside recycling at the household level. However, as pointed out above, although households now recycle more than ever before, regulatory and information initiatives have not convinced households of the need to reduce the amount of waste they are generating to begin with. Economic incentives (rebates for the proper disposal of household

appliances) and disincentives (higher user fees, taxes on disposable products and packaging) are likely to increase the effectiveness of household contributions to achieving municipal waste targets.

Some OECD governments provide *information* to households on voluntary waste minimisation strategies, including guidance on making careful product purchases (e.g. re-use potential, product life, minimum packaging, minimum toxicity, "no-buy" options). Several of the case studies also noted the potential for reducing household food and packaging waste by providing information to strengthen consumer food conservation and preparation skills.

In view of likely demographic trends towards highly individualized meals and sustained consumer demand for convenience and pre-prepared foods it is clear that efforts to limit waste generation at the household level must be supported by product policies that encourage energy and materials efficiency while ensuring high levels of food quality and safety. This underlines the importance of medium- and long-term government promotion of future *technologies and infrastructures* that will support sustainable household behaviour. Waste policies need to be better integrated into an economy-wide approach of lifecycle resource management to reduce the material input into the economy and achieve closed materials cycles. At the household level, resource efficiency should translate into a reduced flow of materials into the household to begin with. In the area of food consumption, some OECD governments have begun to develop technical assistance programmes to improve waste reduction and management skills in the processing and food service sectors. Measures will also be needed to improve recycling of packaging wastes and composting organic wastes. The low recovery rates for plastics are of particular concern, and call for advances in private sector technology and public policy to make the safe reuse of plastic packaging possible (e.g. minimum recycling content for food and cosmetic packaging). Some countries, such as Germany and the Netherlands, have started public composting programmes where the municipality collects organic waste from households: in Germany 35% of the households have a bio-waste container.[14]

In the US, experts in waste management say that the infrastructure built to process recyclables and organics is more than capable of handling greater volumes but market forces (the lack of markets for recycled plastics, for example), political realities, and budgetary constraints stand in the way (Kauffman and Chevrot, 2000). Nevertheless, policies promoting the use of recycled products are emerging at both state and federal levels. For instance the California legislature is considering amending its rigid packaging recycling law to cover food and cosmetic packaging. Plastic packaging intended for use with food or cosmetics was originally granted a temporary exemption from the requirements of the law, and then provided a permanent exemption in 1996. Removing the exemption would provide expanded markets for recycled plastic resins. The proposed amendment would increase the minimum required recycled content of packaging and could require minimum recycled content for food and cosmetic packaging, along with all other types of plastic packaging. Other states including Oregon and Wisconsin have introduced similar laws. The industry does face barriers to implementation. Food and cosmetic product manufacturers are hesitant to use recycled content in plastic packaging unless their resin suppliers have obtained specific clearance from the Food and Drug Administration that the proprietary process used to produce the recycled resin is acceptable. Although the FDA has issued such clearance in a few cases over the past several years, the process can be lengthy, requiring extensive extraction testing and review by the Agency that can easily exceed a year. This slows the arrival of adequate supplies of recycled resin on the market. Complicating implementation further is the potential for different requirements across states. For the food industry, meeting various regulations and packaging requirements would be a considerable challenge. As more states choose to mandate recycled content of packaging, there will be increased interest in uniform standards to be set at the national level.

[14] See the OECD Sector Case Study on Household Energy and Water Consumption and Waste Generation, OECD General Distribution Document EPOC/ENV/WPNEP(2001)15.

Reducing GHG Emissions from Household Food Choices

There are no policies in place in the case study countries specifically designed to address the climate change impacts of food choices at the consumer level, although a range of policies have been developed or are in the making to address the GHG impacts of food production and processing and transportation in general. Where these policies (e.g. carbon taxes on transportation fuel) have an impact on food prices or availability they could have an impact on consumer choices. Energy and transport efficiency measures at the household level will also have an effect on emissions attributable to the household sector, but are generally not packaged to the public as part of local or national climate change strategy.

One possible way of raising consumer awareness of the GHG impacts of their food choices is to take advantage of food labels that give product origins. Place of origin labels have become more common in many OECD countries following the recent series of food safety crises and rising consumer concern about where and how their food is produced. Place of origin labels give some indication of the distance any particular food item has travelled (but not the mode used) before appearing on the store shelves, and thus can provide partial information on GHG impacts. However, because production methods are as important as transport distances and modes in determining GHG emissions, to provide a thorough evaluation of products "GHG labels" would also need to communicate production information. Thus while place of origin labels might help a European consumer choose between an organic apple produced in France over an organic apple produced in New Zealand, it would be more difficult to use such labels to choose between products produced locally but through energy-intensive (e.g. greenhouse) methods and products produced farther away but with less intensive inputs.

4.4 Influencing the upstream impacts of household food consumption patterns through information

Food labelling and information

Although much of the infrastructure and technology that shape the environmental impacts of the food sector lay beyond the realm of influence of households, over time consumer market behaviour has an influence. Food labelling is a crucial aspect in empowering consumers to evaluate their options and "vote with their pocketbook".

The national studies document a range of attitudes to food labelling, ranging from a high awareness and demand for all types of information in Austria, fairly high but partial awareness of key food labels in Sweden, unclear and overabundant information on organic foods in particular in the US, and a new but growing role for food labels in Poland. Food labels share the same difficulties as ecolabels on other consumer goods -- to be most useful to the consumer the information has to be relevant, concise, understandable and credible. In contrast, the information "environment" today is characterised by a rapid increase in the number of individual producer, regional, association, and official labelling programmes with their own set of criteria and often no third-party verification. In the US, for example, although the price differential for organic produce is a dissuasive factor for some consumers, the low penetration rate of organic foods is also influenced by the mass of information provided by private and state-level labelling initiatives. Consumer confusion on what really qualifies as "organic" food prompted the US Department of Agriculture to issue national standards in February 2001 for the production, handling, and processing of organically grown agricultural products. The standard is intended to facilitate the burgeoning market for organic products – one of the fastest growing segments of US agriculture – by simplifying producer certification and reducing consumer confusion. US consumers will begin to see the new organic labels in their local stores by mid-2001 with full implementation by 2002 (USDA, 2001).

In Austria Payer et al attribute the growing market share for organic produce in part to the creation of private, store-backed labels for organic foods in major hyper-market chains (Payer 2000). This

strategy effectively transfers the credibility issue to the store's reputation rather than to each individual item on its shelves and thus facilitates consumer decision-making. The Austrian national study calls for further work to support on-going pilot studies of selected eco-rating systems for food. Sweden is participating in a Nordic cross-sector project on food labelling, under the aegis of the Nordic Council of Ministers, and is running a government enquiry into consumer information on consumer goods.

At the regional level, a 1999 EU decision requires food producers to indicate on food labels if their products contain genetically modified (GM) ingredients exceeding one percent. The decision was intended to facilitate a common European labelling system. In a separate decision, EU also agreed a regulation requiring manufacturers to label products containing additives or flavourings derived from GM products. These directives followed existing EU rules that required GM food labelling but did not set a threshold level below which labelling was not required. Some EU member states already oblige retailers to label GM ingredients in their products, although some retailers operate to stricter thresholds than agreed by the EU (Environment News Service, 1999). The EU also agreed separate regulation allowing producers to obtain a "GM-free" label. In practice, however, most products fall in the grey area between the two thresholds and remain unlabelled.

The effectiveness of food labelling in addressing information asymmetries in the market and in stimulating more environmentally sustainable food production and consumption patterns and depends on a number of factors, including the type of information involved and the level and distribution of the costs and benefits of providing that information (Golan, Kuchler and Mitchell, 2000). The US National Organic Standard, with a government-mandated certification process behind it, for example, is expected to be effective in reducing transactions costs between farmers and food manufacturers and in facilitating consumer decision making. The standard responds to a perceived information gap in the market place, while recognising that consumer preferences for organic food differs, allowing preferences and purchases to be more closely matched. The environmental impact of the Standard will be more modest. Organic food production represents only a marginal portion of world agricultural production. As a result, the net environmental benefit from organic labelling will be measured by the extent that it causes organic production to grow (Golan, Kuchler and Mitchell, 2000). Moreover, while organic production of some food products is often environmentally preferable to conventional intensively-produced food, it is not possible to generalise the net environmental and social impact of organic production versus sustainable, or integrated, agricultural techniques (which are usually not indicated on food labels) (Jungbluth and Frischknecht, 2000). Other government tools (e.g. bans, quotas, production regulations or standards, Pigouvian taxes) will be more effective at promoting widespread progress towards sustainable agriculture.

Although environmental labelling may not be the best tool for promoting environmental change labelling still may be a good second best policy where political or regulatory consensus is difficult to achieve (Golan, Kuchler and Mitchell, 2000). This is currently the case for GMO labelling. Golan et al argue that although regulation targeted directly at controlling potential environmental externalities of GM technology "is probably a better policy than labelling…the wide variety of theoretical costs and benefits of GM technology, all with varying and unknown probabilities of occurrence, may argue for labelling as one of the best political options for dealing with concerns about biotech consumption and production (and may explain why labelling continues to be debated.)"

Information campaigns

Apart from labelling consumer information campaigns contribute to consumers' general awareness and understanding of food and environmental issues. In Austria such campaigns are mainly undertaken by environmental and consumer protection organisations, but are often supported by public funds. One of the more successful examples is the "Earth and Hearth Tales" interactive exhibit which aims to deepen and revise the visitor's knowledge of organic agriculture and healthy food. The exhibit has targeted communities and schools, and provides supplementary exercise books and materials for students and teachers, workshops and vocational training seminars for teachers and farmers. Due to the large

popularity of the initiative and “Earth and Hearth Tales” box, containing a wealth of games, information materials and suggestions pertaining to organic agriculture and nutrition was developed. Also in Austria, the Austrian Ecology Institute, with the support of the Federal Ministry of Agriculture, Forestry, Environment and Water Management, published a consumers guide including an “eco-ranking” for more than 160 selected product examples from all the important food product groups (Gupfinger et al, 2000 in Payer et al, 2000). Based on several international eco-balances and similar studies, the eco-ranking covers the categories of transport, agriculture (plant and animal production), packaging, processing and preservation. The ranking is supplemented by further rankings with regard to health and social tolerance, background information on the different product groups and shopping hints.

Using consumer information to motivate upstream environmental improvements

Labelling can also play a role in motivating improvements in production processes. Whether food products are subject to mandatory labelling or market pressures are such that producers feel the need to voluntarily label their products, the transparency this brings can stimulate manufacturers to look for ways to improve their environmental impacts.

The US study also shows the potential for using information to place additional pressure on food processors and the food service industry to reduce the environmental impacts of their activities through the extension of the Toxic Release Inventory (TRI) programme. Contained in section 313 of the Emergency Planning and Community Right-to-Know Act of 1986, the TRI programme requires industrial facilities to submit an annual report of listed toxic chemical releases to the environment. The reports must contain the quantities of releases as well as the maximum amount of the chemical on-site during the calendar year and the amount of wastes transferred off-site. The TRI list now exceeds 650 toxic chemicals. While TRI was viewed with scepticism at the time of its passage, the corporate and grassroots response has been extraordinary. It has helped communities to understand the impacts of local industries on their environment, and has also contributed to improved product and process "stewardship" by many companies. Major corporations, confronted with publication of their annual releases and anticipated reactions of local communities, pledged significant reductions in toxic emissions and commenced intensive waste reduction initiatives (Shameek Konar & Mark A. Cohen, 1997; James T. Hamilton, 1995 in Kauffman and Chevrot 2000). While TRI is currently limited to industrial facilities, it suggests the possibility of a similar initiative for the service sector. Reporting requirements that focused on toxic emissions, energy use, materials throughput, and solid waste could lead to improved environmental behaviour and stewardship in the food service industries as well as to consumer education about the environmental impacts of food consumption (Kauffman and Chevrot 2000).

Food advertising: a role for governments?

Each of the national case studies notes the role of advertising in providing consumers with information about their food choices. The Swedish study in addition describes Swedish government regulation specific to advertising, in this case advertising to children. Although none of the case studies argue for new or additional controls on advertising, the Polish, the US and Swedish studies nevertheless note the correlation between advertising dollars and consumer demand for certain food products. Another issue raised, but not discussed in depth is the role of publicly funded generic advertising for specific food products. Generic advertising in the US, for example, raised fluid milk sales about 6.0 percent, or 18.1 billion pounds, between September 1984 and September 1997. Sales of cheese rose by about 6.8 million pounds (milk equivalent) in the same period because of increased generic advertising. An assessment of 15 cents per hundredweight of milk sold commercially, mandated by the Dairy and Tobacco Adjustment Act of 1983, funded the advertising (USDA, Economic Research Service, Analysis of Generic Dairy Advertising, 1984-1997 ERS-TB-1873, February 1999). Support for generic advertising funded by public money could also be tied to environmental performance.

5. CONCLUSIONS

The four country studies demonstrate the link between day-to-day household decisions about food and environmental impacts both at the household level and further upstream in the food processing and production sectors. Although the case studies cover only four OECD countries, in view of the globalising food market and the increasingly similar set of economic, social and demographic factors that are shaping most OECD countries, it is not unreasonable to assume that many of the trends and impacts documented here are common to other OECD countries as well. There are several areas where cross-country exchange of experience could help OECD countries move forward to address the environmental impacts of household food consumption, particularly in the areas of food-related energy use, food and packaging waste reduction and management; and transportation rationalisation.

The case studies have documented direct household impacts from household food consumption patterns in the areas of energy consumption, waste generation, transportation and GHG emissions and pointed to how trends in consumer demand for certain food products and services are linked to impacts higher in the food system chain. In the short- and medium-term, it is reasonable to expect that the principle factors driving food consumption patterns, as summarised in the needs-opportunities-abilities model, are here to stay. As a result, in the short-term government measures targeted directly to consumers will need to work within these patterns to increase energy efficiency along the entire food production and consumption cycle, increase source reduction and recycling of packaging and food waste, and to rationalise food transportation needs. In the longer-term, governments and other actors can use information and economic instruments to raise consumer awareness and understanding of the ways in which they can make food choices with lower environmental impacts.

In some cases government policies to influence impacts from food consumption patterns will need to be placed in a wider context related to overall household behaviour. It is likely be more effective to work with households on their complete transport and energy needs than to focus uniquely on food related issues. Information provided in the country studies provides useful clues on which food-related behaviour patterns could be most open to information or other measures (e.g. a combination of consumer education on the availability of energy-efficient household appliances and how to use them could further decrease household energy consumption).

Governments should make greater use of indicators to identify key environmental impacts from household food consumption and to monitor the effectiveness of policies to reduce those impacts. This study recommends seven indicators that focus on key impacts and that can be measured with currently available data. Additional work could be based on this core set of indicators to develop generic quantitative indicators that could be used to measure environmental trends across OECD countries.

To have an even larger impact governments will also need to promote technology, product and service innovations in the primary production, intermediate (processing, service, retail, distribution), and waste disposal sectors to maximise resource efficiency and reduce releases to the environment. The role of food and appliance retailers and food service providers is an area that has been inadequately examined to date. Retailers and food service providers anticipate and respond most quickly to consumer demands and can help them identify environmentally beneficial products. They can also influence the supply chain that determines what is offered to consumers by increasing awareness of value added products that are

environmentally sound. Retailers and food service providers can also make significant reductions in energy consumption and waste generation. The country studies give examples of technical support programs to the food service and retail sectors in the US and of the promotion of environmental management systems (EMS) in the food sector in Sweden. Voluntary initiatives could play an expanded role in these areas. In the interest of maintaining a wider perspective on net environmental impacts, efficient government measures should be targeted first to those sectors with large or concentrated impacts. Energy use and environmental impacts from the transportation of food are key points of focus for the food processing, distribution and retail sectors. Energy use and waste generation are important areas for the food service sector.

The case studies raised other issues that are important for determining the net environmental impact of food consumption patterns. Trade-offs in energy consumption between different actors in the food sector (from producers down to waste disposal firms) is one such area. In view of relatively high rates of refrigerator/freezer ownership, for example, household energy demand for food consumption could stabilise or decrease if more energy efficient cooking appliances and practices are adopted. This takes as given that consumers will continue to demand more pre-prepared foods that require little cooking at home. The net environmental effect from energy consumption from such a trend would require additional analysis, however, to take into account energy consumption for food processing, chilled conservation, distribution and storage, and disposal of food packaging. Similarly, the net effect of changes in food preparation and distribution on both freight and personal travel patterns would have to be further investigated before it would be possible to estimate the real environmental impact of household demand for certain food products and services and market driven modifications in the structure of the food sector. This type of analysis would require an integrated analysis of both food consumption and production systems in order to identify the most effective points for technological innovation or policy intervention.

ANNEX 1 POLICIES THAT AFFECT CONSUMER BEHAVIOR

Source: K. Ralston in America's Eating habits: Changes and Consequences, USDA/ERS May 1999, in Kauffman and Chevrot 2000

Farm assistance programs (current and historical)			
Program/regulation	**Food affected**	**Effects on dietary choices**	**Size of effects**
Price and income support programs	Wheat, rice, feed grains, oilseeds, dairy, peanuts, sugar	Surplus purchases reduce marketed supply, increase price Acreage restrictions reduce supply, increase price Deficiency payments may increase supply, but payments usually linked to acreage restrictions Milk marketing orders set regional minimum prices for milk for different uses; may lead to below market prices for cheese	Small- low price elasticity of demand for affected commodities, feed crops, only part of meat, poultry, dairy, egg prices. Can be large for a pop. Group when surpluses are distributed to that group Small due to low price elasticity of demand.
Fruit/vegetable marketing orders	Federal orders: 27 fruits/veg., and spec. crops, Others covered in state orders	Some marketing orders set quantity limits, which may limit availability, but also increase demand by reducing quality variability	No estimates available
Research and Promotion	Federal programs: beef, dairy, eggs, honey, mushrooms, popcorn, pork, potatoes, soybeans watermelons, wheat	Producer assessment fund generic advertising; can increase consumer demand for the commodity	Dairy Beef: mixed evidence Catfish: large Orange Juice: limited

Food safety			
Program/regulation	**Food affected**	**Effects on dietary choices**	**Size of effects**
Food inspection	All foods	Safety requirement may increase costs, and price of foods Confidence in the food supply may increase demand	Small impact on costs, except for small firms Effect of lower consumer confidence large in short run
Food additive approval	All processed foods	Can increase shelf-life, lowering costs, can provide characteristics of interest to consumers, increasing demand Approval process expensive, restricting development to high profit foods, but maintains consumer confidence	No estimates available, but demand effects could be large for some additives leading to low fat or fat free foods No estimates available
Pesticide regulations	All foods	Restriction may decrease supply, increase price Confidence in the food supply may increase demand	Overall impacts small, may be large for certain varieties Effects of lower confidence large in short run
Animal drug approval	Meat, poultry, eggs, dairy, farm raised seafood	Approvals allow use of drugs, which increase supply, decrease costs of productions If consumers don't accept new drug, could decrease demand	Small- low farm-price-to-retail-price ratio, low price elasticity of demand Effects of consumer concerns usually temporary

Information and Other regulations			
Program/regulation	**Food affected**	**Effects on dietary choices**	**Size of effects**
Labels/advertising	All processed foods (fresh food labels voluntary, but any labels standard format)	Information affects demand for foods Information affects formulation decisions Label regs. Increase costs, price of foods	Small effect of information Effect of formulation changes may be larger Small effect on price except for small firms
Standard of identity	Over 200 processed foods	Prior to revisions, lower fat versions required to be labeled as imitation or other pejorative term which suppressed demand for more healthful products	Revisions may have had a large effect for some items (low fat ice creams/ hot dogs)
Quality grades	Dairy, eggs, poultry, beef, many fruits and vegetables	Standardization lowers information costs from marketing Where grades used at retail levels (such as for beef), grade name can affect consumer demand	No estimates available
Environmental controls	Potentially all foods	Env. controls could increase costs (or prevent cost-decreasing changes)	Could be large for individual fruits/ vegetables with high price elasticity of demand
Worker safety	all foods	Protection of farm workers and food storage and processing personnel could increase costs	Small for farm workers; other estimates not available
Protection of competition	all foods	Restrictions of mergers prevent monopoly power, which could decrease supply and increase prices. Increased consolidation may also result in greater efficiency, which could lower prices	No estimates available
Trade policy	all traded foods	Policies that restrict imports or encourage exports decrease domestic supply and increase price	Small for dairy and sugar with low price elasticity of demand; Larger for fruits and vegetables with higher price elasticity of demand

ANNEX 2 COMPARATIVE ANALYSIS OF METHODOLOGIES FOR EVALUATING ENVIRONMENTAL IMPACTS FROM HOUSEHOLD FOOD CONSUMPTION

1. Cumulative Energy Requirements Analysis

Introduction

Cumulative Energy Requirements Analysis (CERA) aims to investigate different energy uses over the life cycle of a given amount of a product or service. This includes the direct uses and the indirect or "grey consumption" of energy due to the use of e.g. construction materials or intermediate products. This methodology has a long tradition (BOUSTEAD & HANCOCK 1979, LEACH 1976, PIMENTEL 1973, PIMENTEL & PIMENTEL 1996, SINGH 1986). Guidelines for cumulative energy requirements analysis have been published in Germany by VDI (1997). Papers are published i.e. in ENERGY POLICY and other journals. This type of methodology is also described as *process chain analysis* as it looks stage by stage at the whole process chain of a product or service.

Life cycle stages and emissions investigated, indicators and aggregation principles

Generally all stages of the life cycle that are related to direct or indirect energy use are accounted for in a CERA. The primary energy requirement for a given product or service, expressed in joules, is used as an indicator. The primary energy requirement of different energy carriers (e.g., electricity, gasoline, and firewood) is determined by adding the heating value of the energy carrier and the energy required for its production and delivery. The heating value of gasoline, for example, is 42.8 MJ (mega joule) per kilogram while an additional 17.8MJ/kg is required for its production and delivery. Thus, the total cumulative energy requirement amounts to slightly more than 60MJ/kg.

Different concepts for determining the primary energy requirement exist. In contrast to the CERA-concept, energy statistics such as those used by BP Amoco (1999) consider only the heating value of the fossil fuels and disregard the share of energy used for their production and delivery. For CERA-calculations one may choose the lower or upper heating value of energy carriers, where the latter includes the evaporation energy of the vapour present in flue gas. It is also possible to distinguish between energy requirements of renewable and non-renewable resources. Finally different ways exist for calculating primary energy equivalence for electricity from nuclear, hydro, solar, wind, etc.

Data requirements and availability

Because energy use is an important economic factor it is normally well documented. Many publications provide data for the energy use of certain background processes based on a long tradition of cumulative energy requirements analysis (e.g. CARLSSON-KANYAMA & FAIST 2000, PIMENTEL & PIMENTEL 1996). As a result data availability is generally not a major problem, although databases are sometimes very old. Attention should be paid to the approach used in databases to aggregate different types of energy resources.

Case studies on food consumption

There are many case studies on energy use related to food consumption (e.g. CARLSSON-KANYAMA & FAIST 2000, COLEY *et al.* 1997, FAIST *et al.* 1999a, LEACH 1976, PIMENTEL 1973, PIMENTEL & PIMENTEL 1996, SINGH 1986). These studies have identified fertiliser production and direct fuel use for tractors as important energy consumers in the agricultural sector. Other important points for energy consumption along the life cycle of many food products are transportation between different processing or commercialisation stages, cooling and heating of food products during processing, retailing and consumption.

EXAMPLE: CUMULATIVE ENERGY REQUIREMENTS ANALYSIS

ZAMBONI (1994) investigated the cumulative energy use in the life cycle of different food products for a Swiss consumers organisation. The analysis reveals for example that the consumption of fresh peas from Switzerland requires 3.6MJ/kg while peas imported from Egypt require 45MJ/kg because of the high energy consumption from air transport. Tomatoes from a Swiss greenhouse require three times more energy to produce than the ones produced on open-ground. Production of lamb meat in Switzerland consumes over 60MJ/kg, but if it is imported by air from New Zealand, an additional 226MJ/kg are consumed due to transportation. The total energy use for 1 kilogram of NZ lamb consumed in Switzerland is equivalent to the energy content of 6.8 litres of fuel oil. This analysis of cumulative energy requirements has made it possible to issue guidelines to Swiss consumers on important energy use impacts of their food consumption decisions.

Summary of strengths and weaknesses and utility for policy making

The reduction of energy consumption is one important prerequisite for sustainable development. As several environmental problems, e.g. climate change or nuclear waste disposal, are linked to energy use, this indicator can serve as a yardstick for improvements. It is also easily understandable for consumers, politicians or managers of private enterprises. As a result, cumulative energy requirements analysis is useful for gaining an overview of the environmental impacts in the life cycle of a food product and for an initial comparison of single products. For some household appliances e.g. cook stoves, energy use is the single most important factor for determining environmental impacts. The total energy use in a country, whether for specific sectors of the economy or for single products, is a good yardstick to measure and monitor the success of policy measures.

Nevertheless, energy use does not give a full picture of all environmental impacts in the life cycle of food products. Eutrophication due to intensive animal production, for example, is one problem that is not captured by energy use in food production. Furthermore the environmental impacts are different for the different energy resources. The impacts of coal use in relation to energy content, for example, are normally more severe than those due to using natural gas. Thus, cumulative energy requirements analysis cannot be the unique methodology used for evaluating the environmental impacts of food consumption patterns.

2. Input-Output Analysis (IOA)

Introduction

Input-output analysis aims to describe and analyse the structure of an economy in terms of the interdependence among its different sectors. This description uses monetary units and can be extended to

other flows, e.g. of energy resources or environmental pollutants (e.g. IOEA-input-output energy analysis). As a result, the direct and indirect emissions of each economic sector such as agriculture, the chemical industry or restaurants, can be calculated and expressed as an environmental impact per economic value also known as total **energy** (or environmental) **intensity** of the different sectors.

An input-output model provides a framework (transaction matrix) for tracking the payments made by industries to other industries, and by consumers to industries, in the production of commodities and services. Table 1 shows a fictitious example for the transaction matrix. One can read from this example that the energy sector consumes energy and materials for each 10CHF in order to produce a total of 40CHF. Out of this, products equal to a value of 20CHF are consumed for the final demand.

The economist Wassily LEONTIEF (1936) developed a method of inverting the transaction matrix so that the effect of any given set of consumer purchases on industry expenditures throughout the economy can be calculated (CHEVROT 2000). The economic method can be extended in different ways in order to investigate the environmental impacts caused by different economic sectors. In a first step the direct emissions or energy uses of each sector are investigated in the input-output table. The energy sector uses 80MJ of primary energy per year in our example (as shown in the second last row of Table 1), while the material sector does not use energy resources (e.g. crude oil or hard coal) directly. This sector consumes energy indirectly while purchasing products, for example gasoline or electricity, from the energy sector.

The question to be answered is how much energy is used by the material sector indirectly due to the consumption of products from the energy sector? The matrix with the economic and environmental flows can be inverted in a mathematical operation. This results finally in a figure for the energy intensity of the final demand. For the example in Table 1 this results in 3.2MJ/CHF or 1.6MJ/CHF that is used to produce goods (energy or material, respectively) for final demand (products consumed by consumers). Also the total indirect energy demand of each sector can be calculated as shown in the last column.

Table 1 Example of a simple input-output analysis in a fictitious economy.

The input-output table is shown in the bold frame in the upper left part. Extensions for the IOEA are in *cursive* letters (WILTING 1996:31).

		energy	materials	final demand	total	*energy intensity of final demand*	*indirect energy use to meet the final demand*
		CHF	CHF	CHF	CHF	*MJ/CHF*	*MJ*
energy	CHF	10	10	20	40	*3.2*	*64*
materials	CHF	10	0	10	20	*1.6*	*16*
primary inputs	CHF	20	10	-	30		
total	CHF	40	20	30	-		
direct energy use	*MJ*	*80*	*0*				
direct energy intensity	*MJ/*	*2*	*0*				

The calculated energy (or environmental) intensity can be used in a subsequent step to calculate the impacts of certain consumption patterns and the share of different need fields (e.g. nourishment, mobility, etc.). Given expenditures for commodities from different economic sectors (e.g. food, transport, etc.) these monetary flows can be multiplied by the energy (or environmental) intensities and summed. Input-output research is published in journals dealing with political economy and cumulative energy requirement analysis.

Life cycle stages and emissions investigated, indicators and aggregation principles

The IOA methodology includes all stages of the life cycle that generate monetary flows (e.g. fertiliser production, transport) as well as spending for taxes, services, or office materials, which are often neglected by the process-chain based methods. The IOA does not cover impacts of processes without an economic flow, e.g. the composting of wastes in one's own garden. The kind of pollutants that can be covered by the IOA methodology depends mainly on the availability of statistical data for total direct emissions of all sectors in the economy.

Emissions of certain substances (e.g. CO_2) or energy use generally serve as indicators. In countries with a good database for emissions in different economic sectors, e.g. the USA, it is even possible to cover additional pollutants. Sometimes different emissions related to one environmental problem are aggregated by using characterisation factors, such as the global warming potential for greenhouse gasses. Generally, however, the objective is not to aggregate all types of investigated emissions and resource uses to one indicator.

Data requirements and availability

The methodology requires good general, and environmental, accounting data for the IO table and the linkages between economic activity and environmental impacts. As more sectors are distinguished in the input-output table, more accurate calculations for environmental analyses become possible. The time spent on an IO analysis is high at the beginning due to data requirements. In some cases (e.g. the USA) it is possible to cover a range of different emissions while in other countries (e.g. Switzerland) it is difficult to trace even energy use.

Case studies on food consumption

CHEVROT (2000) describes an input-output analysis of food consumption in the USA (Figure 1). Other known case studies have investigated the overall household consumption or energy use in different sectors of one country. These studies concluded that food consumption patterns were responsible for 15% to 20% of the total impacts caused by household consumption (KNOEPFEL 1995, NORRIS 1998, WEBER *et al.* 1996a, WEBER *et al.* 1996b, WILTING 1996).

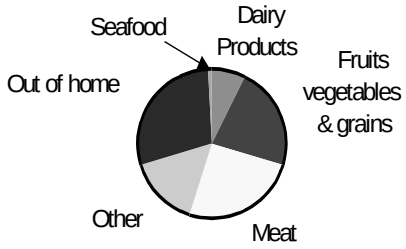
Summary of strengths and weaknesses and utility for policy making

The IOA methodology is valuable for investigating energy use (or environmental impacts) of average total consumption patterns in an economy because it is an easy method to calculate the energy requirements (environmental impacts) for average consumer goods. Food consumption is only one of the different fields that has been investigated. By using monetary flows IOA enables analysts to generalise data that would otherwise be difficult to compare. Using monetary flows also renders the analysis more comprehensive as well as easily comparable over time. The methodology is also useful for assessing the share of different economic sectors or household activities in the total energy use or emissions of certain pollutants. It can also be used in forecasting assessments that model the impacts of policy measures.

Fig. 1 Greenhouse gas emissions of different sub-sectors due to food consumption investigated with an input output analysis for the USA (Brower & Leon 1999).

EXAMPLE: INPUT-OUTPUT ANALYSIS

The Union of Concerned Scientists conducted an Input-Output Analysis to explore annual emissions of greenhouse gases (tons of carbons of CO_2, methane, and nitrous oxide) from food production through consumption in the USA (BROWER & LEON 1999, cited in KAUFFMAN & CHEVROT 2000). Figure 1 shows that the combined consumption of meat, fruits and vegetables contributes most to greenhouse gas emissions from household food consumption patterns. However, the trend in eating away from home (which includes factoring and transportation to and from food service establishments) is also a significant contributor to GHG emissions (BROWER & LEON 1999, cited in KAUFFMAN & CHEVROT 2000:21)



Due to the high level of aggregation, the IOA methodology is not exact enough to calculate and compare the environmental impacts for individual products of an economic sector. Its use depends strongly on the availability of economic and environmental data for the economy in any given country. Thus a high initial effort is required to establish a database. In most OECD countries it is not possible to cover all environmentally significant impacts from food consumption (e.g. eutrophication, pesticide or water use). It is also difficult to transfer the results of an IOA of one country to another or to calculate energy or environmental impacts from imports. Because of these limitations an IOA in most OECD countries will not be specific enough to monitor the environmental impacts of food consumption patterns.

3. Hybrid Analysis (HA)

Introduction

Hybrid-analysis (HA) aims to investigate energy (or CO_2, etc.) intensities of products in a simplified manner. It combines information from an input-output analysis with process chain analysis in order to calculate the energy requirement over the life cycle of a product or service in relation to the average consumer price. Process chain analysis is used to calculate the energy requirement for a range of consumer products. These intensities can then be linked with statistical information on household expenditures for a range of single products in order to analyse different consumption patterns in more detail than is possible with the input-output analysis, which investigates only the energy intensities for whole sectors of an economy.

The investigation of major energy uses along the life cycle of a product is supplemented with information about additional energy inputs from the input-output table. To give an example for tomatoes: the energy use due to the use of fertilisers and fuels for machinery is accounted for directly by investigating the amount used. Other remaining energy uses, i.e. for the construction of farm buildings, are

calculated with the energy intensity of the economic sector (i.e. construction services) and the spending of farmers for these items.

The methodology has been developed in the Netherlands (VAN ENGELENBURG *et al.* 1994) and all types of consumer products have been investigated (BIESOT *et al.* 1995). Some case studies have been conducted in other countries (WEBER *et al.* 1996a, WEBER *et al.* 1996b, ZACCHEDDU 1997).

Life cycle stages and emissions investigated, indicators and aggregation principles

All parts of the life cycle, including expenditures for taxes, services, etc., are investigated in a HA. The detail of investigation depends on the information available and the required precision. Besides the energy requirement, some studies also investigate emissions of air pollutants due to the combustion of energy carriers (WEBER *et al.* 1996a, WEBER *et al.* 1996b) or include even the direct emissions of greenhouse gasses during food production (KRAMER *et al.* 1999).

The indicators used in HA are primary non-renewable energy resources and pollutants like CO_2, NO_x or SO_2. The level of detail depends on data availability for the input-output analysis. Generally there is no aggregation of different pollutants other than the calculation of the global warming potential.

Data requirements and availability

The initial data requirement for using the hybrid-analysis in a country is relatively high. A prerequisite is a detailed input-output analysis including data on energy use and emissions and information about the energy uses for the production of a range of basic products (e.g. fertiliser, pesticides). However, once a database has been established for a country it is easy to investigate additional products.

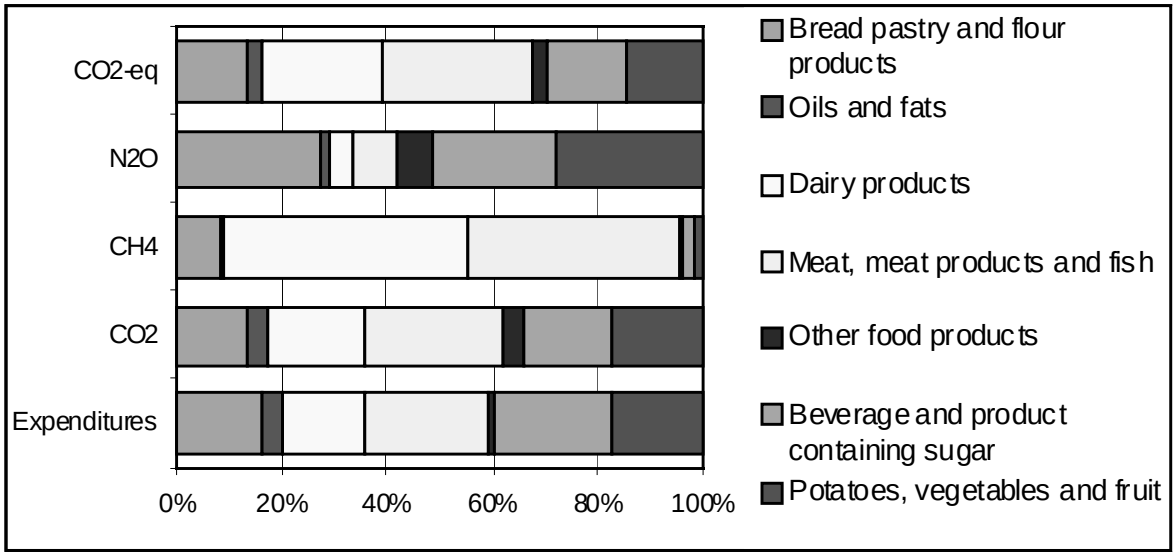
Case studies on food consumption

Extensive case studies on food consumption based on a hybrid-analysis have been published mainly in the Netherlands (Figure 2). They show for example that lower environmental impacts for cooking pre-prepared products can in some cases compensate for the higher impacts during the production stage (BROUWER 1998, KRAMER 1998, KRAMER & MOLL 1995, KRAMER *et al.* 1998, 1999).

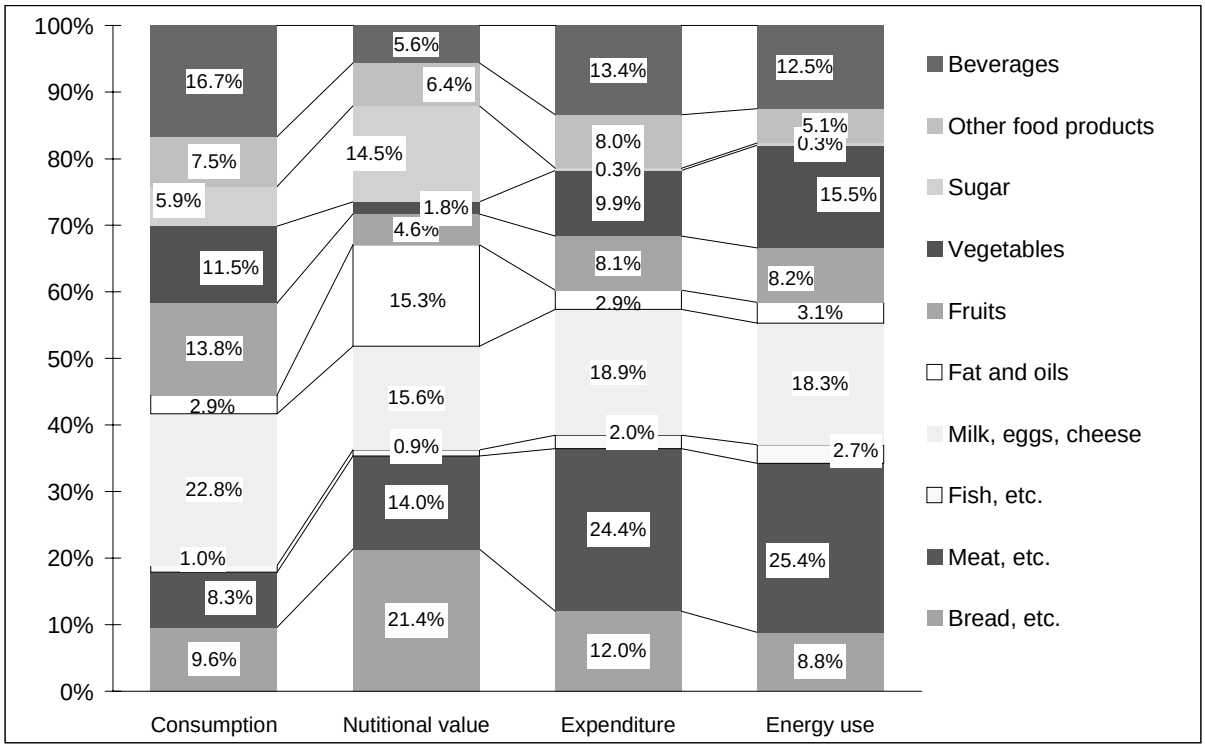
Distribution of Dutch annual spending over seven food product categories and contribution of these categories to the greenhouse gas emissions related to Dutch food consumption (Kramer et al. 1999)

EXAMPLE: HYBRID ANALYSIS OF SWISS FOOD CONSUMPTION PATTERNS

Figure 2 shows the results of a hybrid-analysis for different greenhouse gases given by KRAMER *ET AL.*(1999) for Dutch consumption patterns in 1990. Meat accounts for 23.5% of the expenditures, but for 8.2% and 40.4% of the N_2O and CH_4 emissions due to food consumption respectively. Milk and vegetables are other important product groups with regard to the greenhouse gas emissions.



EXAMPLE: HYBRID ANALYSIS OF SWISS FOOD CONSUMPTION PATTERNS (continued)



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Summary of strengths and weaknesses and utility for policy making

The hybrid-analysis is a good methodology to efficiently investigate energy use or single emissions for a wide range of single consumer products. The possibility to combine these data with household expenditure statistics is an advantage exclusive to this methodology. The hybrid-analysis is useful for evaluating the share of different products (e.g. meat, vegetables, etc.) in energy use or for some environmental impacts of consumption patterns or diet choices. The methodology can also be used to analyse the development over a period of time and to forecast impacts due to changes of consumer behaviour.

The main drawback of HA is the high initial effort for the initial establishment of an IO-database for a country. The analysis is also not very specific with regard to the environmental impacts considered.

4. Life Cycle Assessment (LCA)

Introduction

Life cycle assessment (LCA) (some authors use the term life cycle analysis) aims to investigate and compare all types of environmental impacts that occur in the life cycle of a product or service. The methodology grew out of cumulative energy requirements analysis, expanding to include an increasing number of emissions of pollutants and consumption of resources. Normally LCA aims to analyse and compare different products, processes or services that fulfil the same utility (e.g. greenhouse tomatoes against open-ground tomatoes). It is used for hot spot analysis, product or process improvement, marketing and environmental policy.

The International Organization for Standardization (ISO) (1998) standardises the basic principles. An LCA consists of four steps. The *goal and scope definition* describes the underlying questions, the system boundaries and the definition of a functional unit for the comparison of different alternatives. The flows of materials and resources are investigated and recorded in the *inventory analysis*. The elementary flows (emissions and resource consumption) are described, characterised and aggregated during the *impact assessment*. Final conclusions are drawn during the *interpretation*.

The Society of Environmental Toxicology and Chemistry (SETAC)[15] hosts the scientific community work on LCA. The LCA Network on Food[16] (LCAnet Food) serves as a basis for European researchers in the field of LCA for food products. Papers on LCA methods and case studies are published by the INTERNATIONAL JOURNAL OF LCA, the JOURNAL FOR CLEANER PRODUCTION, the JOURNAL OF INDUSTRIAL ECOLOGY, and the ENVIRONMENTAL IMPACT ASSESSMENT REVIEW.

Life cycle stages and emissions investigated, indicators and aggregation principles

The methodology generally investigates the full life cycle of a product from "cradle to grave" including the life cycle of all pre-products and energy carriers used. All types of environmental impacts, e.g. emissions into water, air and soil as well as resource use (primary energy carrier, land, etc.) are accounted for. Some authors include also additional effects, e.g. direct health hazards for employees in the production facilities.

An intermediate result of an LCA is an inventory table with data for the emission of hundreds of single substances and for many resource uses. Impact assessment methods used for the aggregation of these results are proposed for example by BRAND *et al.* 1998, GOEDKOOP 1995, GOEDKOOP & SPRIENSMA 2000, HAUSSCHILD & WENZEL 1997, HEIJUNGS *et al.* 1992, HUIJBREGTS 1999, STEEN 1999). These methods consist of standardised procedures for one or more of the following steps (introduced in chapter 2.1): characterisation or damage assessment, normalisation and weighting.

It is necessary to choose an appropriate impact assessment methodology with regards to special emissions in the life cycle (e.g. agricultural chemicals), the region under study (e.g. Europe) and the decision-makers addressed. Often the studies use different impact assessment methods simultaneously in order to see and discuss differences in the outcome.

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15 See www.ecomed.de/journals/lca/welcome.htm and www.setac.org.

16 http://www.sik.se/sik/affomr/miljo/lcanetf.html

Data requirements and availability

Data investigation is usually the most time consuming step of an LCA (JEDVALL 2000:34). But this situation is improving due to the establishment of standardised background databases (e.g. CARLSSON-KANYAMA & FAIST 2000, FRISCHKNECHT *et al.* 1996, GAILLARD *et al.* 1997, JUNGBLUTH 2000, KJER *et al.* 1994, WEIDEMA & MEEUSEN 2000) and LCA software that include these background data. The LCA Network on Food aims to build up a common database for food production.[17]

The agricultural production stage is more difficult to model in LCA than technical systems such as (e.g. coal power) plants due to a number of specific methodological problems. For example, a cow produces milk, meat, manure, leather, etc. but it is difficult to assign or allocate emissions from fodder production to any individual product. In addition, agricultural products are produced by thousands of producers while technical products are often produced in a few facilities. Thus it is difficult to determine the average production parameters such as fertiliser use for so many actors (COWELL *et al.* 1999).

Case studies on food consumption

Some of the first LCA studies investigated packaging materials (e.g. HABERSATTER *et al.* 1998, HUNT 1974, SCHMITZ *et al.* 1995). The results of that work have led to improvements in package systems and materials. Packages are important in the life cycle of some products (e.g. soft drinks or mineral water), but for many agricultural products the contribution of packaging to the overall impacts over the life cycle is small and should not be overestimated (JUNGBLUTH 2000).

CARLSSON-KANYAMA (1999) has used LCA to explore the impacts from food consumption patterns on climate change and ANDERSSON (1998) has investigated different food products in her thesis. JUNGBLUTH (1999) described about 80 LCA case studies on different food products, most of which investigated one single product. Case studies often focus on the agricultural production stage. They show that intensive agriculture production leads to several problems like eutrophication, emission of pesticides, soil erosion and degradation, reduction of water resources, etc. (e.g. AUDSLEY *et al.* 1997, CEDERBERG 1998). JUNGBLUTH (2000) discussed the results of LCA case studies comparing different types of production (e.g. organic, integrated[18] or conventional). Parameters such as the functional unit (e.g. 1kg of product, 1 hectare of agricultural area, 1MJ of nutritional value), fertiliser use, or the valuation of pesticide use[19] influence these results. Environmental impacts rise with the intensity of the production method in the order: organic or integrated, conventional open-ground, and greenhouse production. No clear preference may be given when comparing integrated with organic production because different influencing factors cannot be generalised and must be balanced out in an ecological assessment for different agricultural products (JUNGBLUTH 2000).

17 See http://www.sik.se/sik/affomr/miljo/lcanetf.html.

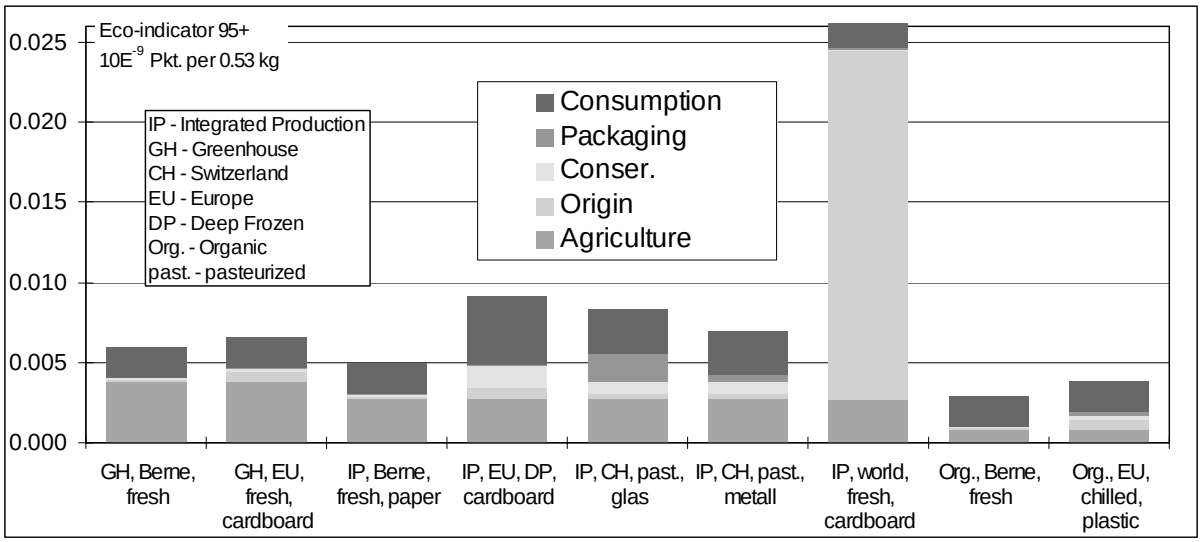
18 Integrated production is a controlled agricultural practice that follows guidelines for the reduced use of fertilisers and pesticides.

19 It is difficult to compare the environmental impacts between different pesticides and to value the impacts in comparison to other toxic substances. It is also difficult to estimate the average uses of pesticides for different products due to the large variety of possible substances (JUNGBLUTH 2000).

Figure 3 Environmental impacts of vegetable purchases with different characteristics investigated in a modular LCA and weighted with the Eco-indicator 95+ method (GOEDKOOP 1995, JUNGBLUTH 2000).

EXAMPLE: LIFE CYCLE ASSESSMENT

JUNGBLUTH (2000) investigated the environmental consequences of vegetable purchases.[20] Figure 3 shows one result using the (slightly modified) impact assessment methodology *Eco-indicator 95+* (GOEDKOOP 1995, JUNGBLUTH 2000). Different characteristics (agricultural production technique, conservation method, origin, packaging and consumption) can be important for determining a vegetable product's overall impacts. The highest impact was from a vegetable flown in from overseas. In such cases, consumers have powerful options to reduce the environmental impacts of their vegetable purchases by not purchasing products flown in from overseas or produced in greenhouses. Depending on the type of food product investigated all stages of the life cycle can be important with respect to environmental impacts. The study also shows the relevance of different pollutants like nitrates, phosphates, pesticides and heavy metals that are not directly linked to energy use. A detailed discussion of the results for single parts of the life cycle can be found in JUNGBLUTH (2000).



Summary of strengths and weaknesses and utility for policy making

The main strengths of the LCA methodology are its holistic approach and the structured procedure for goal definition, data handling and impact assessment. The methodology considers more environmental impacts than all other methods. Thus it fits best for the detailed comparison of products filling the same function but with completely different environmental impacts in the life cycle (e.g.

20 An average environmental impact has been calculated for vegetables from organic, integrated and greenhouse production based on specific single LCA for about ten products each. The results can not be generalised as a general environmental advantage for products from integrated production in comparison to organic products, due to the necessary assumptions for the calculation of the average and uncertainties of the impact assessment method.

imported vegetable from open-air against a regional greenhouse product). LCA is especially useful to identify "hot spots" with regard to the environmental impacts in the life cycle of food products and thus to prioritise and assist policy measures in product policy. It can also be a support to consumers to differentiate between the environmental impacts related to different purchasing decisions.

The main weaknesses of the LCA methodology are the time consuming acquisition of data and the temptation to view LCA as an objective "truth" about all environmental impacts. On the contrary, the application of LCA for decision making is restricted by the specific objective of the assessment and the initial assumptions on which it is based. Some areas of concern for food products (e.g. pesticide use, land use, and use of soil and water resources) are not sufficiently covered in common impact assessment methods. And it is still not possible to quantify all known environmental impacts. As a result of these gaps, additional information is necessary for decision-making in some cases.

A strength, but also a weakness of LCA is the flexibility allowed for using different methods to aggregate emissions and resource uses into indicators. On the one hand, existing differences between impact assessment methods can lead to opposite results of LCAs investigating the same question. On the other hand that flexibility allows the analyst to choose the impact assessment methodology most appropriate for the given questions and needs of the decision makers.

5. Ecological Footprint (EF)

Introduction

The Ecological Footprint (EF) concept seeks to estimate whether the environmental impact of consumption patterns (at household, city, national or global level) stays within the ecological capacity of the Earth's biosphere, or the capacity of a particular region. The calculation of the Ecological Footprint is based on the assumption that most of the resources consumed and wastes generated can be traced back to the consumption of goods and services (WACKERNAGEL *et al.* 2000b). The ecological footprint of a defined population (e.g. a single individual, a whole city, or a country) is expressed as the area of biologically productive land that is used exclusively to produce all resources consumed and to assimilate all wastes generated by that population. Footprints sum up the total biologically productive area required over the life cycle for any given product or service (for a more detailed description refer to WACKERNAGEL *et al.* 1996).

Methodological discussions on the EF concept can be followed in an email group.[21] Examples from the ongoing debate about the pros and cons of this concept have been published in a special issue of ECOLOGICAL ECONOMICS 32 (2000).

Life cycle stages and emissions investigated, indicators and aggregation principles

The EF analysis looks at all stages of the life cycle for the products and services consumed in a certain region and accounts for land uses, resource consumption and emissions of pollutants. The EF of CO_2 emissions is for example calculated by investigating the productive land that is necessary to assimilate the emitted CO_2.

The EF methodology accounts only for resources that can be regenerated within given limits and wastes that can be absorbed by the biosphere at sufficiently low levels. All activities that are systematically in contradiction with sustainability are not considered in the calculations, because WACKERNAGEL *et al.* (2000a) assume that to achieve a sustainable world, their use or emissions needs to be phased out. There is, for example, no sustainable regenerative rate for heavy metals, persistent organic and inorganic toxins, radioactive materials, or bio-hazardous waste.

[21] See http://www.egroups.com/group/ecofootprints/.

Data requirements and availability

There are no specific databases available that can be used in order to calculate the EF for a given food product. However, there are case studies for different countries and for a range of food products consumed by households (e.g. WACKERNAGEL *et al.* 2000a, WACKERNAGEL *et al.* 2000b). The calculations for countries are mainly based on statistical data for i.e. energy use, food consumption and productive land available.

Case studies on food consumption

EF studies generally do not investigate single products, but rather the carrying capacity of a whole region. Food consumption is one of the activities integrated in such an assessment. WADA (1993) investigated tomato production in British Columbia. The ecological footprint of tomatoes from greenhouse is 10 to 20 times higher than the EF from open-air production even though the direct land use of greenhouse production is smaller (cited in WACKERNAGEL *et al.* 1996). WACKERNAGEL *et al.* (2000a) have developed tools to analyse household consumption in different countries and to estimate the footprint of different nations. These tools include data sets for groups of food products like bread, rice, vegetables, meat, etc.[22]

EXAMPLE: ECOLOGICAL FOOTPRINTS FROM SWISS FOOD CONSUMPTION

Table 2 shows an original ESU calculation for the ecological footprint of average Swiss food consumption patterns in 1997 using an EXCEL tool provided by WACKERNAGEL *et al.* (SCHWEIZERISCHER BAUERNVERBAND 1999, WACKERNAGEL *et al.* 2000a). The Table shows the direct and indirect land uses. These land uses are aggregated using primary biomass equivalency factors that represent the relative capacity of different types of land (land in different regions) to produce biomass. In addition, the equivalency factors are scaled by a factor that ensures that the sum for all regions is equal to the global capacity or the globally available land. In this example, the total footprint linked to food consumption is calculated at 22'902 m^2 per Swiss capita, which is shown in the last row (SCHWEIZERISCHER BAUERNVERBAND 1999, WACKERNAGEL *et al.* 2000a). The total ecological footprint of a Swiss citizen considering the consumption of all goods is calculated by WACKERNAGEL *et al.* (2000b) to be 66'000 m^2, while the existing ecological capacity (the productive land in Switzerland divided by the Swiss population) is only 23'000 m^2 (expressed both in area and world average productivity). (Continued on next page.)

Summary of strengths and weaknesses and utility for policy making

The ecological footprint is an awareness-raising concept that helps to clarify the necessity for sustainable development. It was developed to assess to what extent the human economy is overshooting the ecological capacity of the earth. Calculations for certain areas, e.g. cities, show that the area of land available cannot sustainably fulfil the requirements of existing consumption patterns. The main strength of the EF is that it provides a clear indicator that covers the whole life cycle and results that are easy to communicate. Thus the methodology gives a yardstick for the sustainability of lifestyles. It can be used as a proxy indicator if decision-makers accept the underlying assumptions. The methodology might help for example to assess the "sustainability" of trade in particular goods or services, to influence aid and trade

[22] A list of case studies can be found on http://www.bestfootforward.com/.

agreements, or help to inform future international debates about sustainable lifestyles (OECD 1997). However, using EF in this way requires many simplifications.[23]

Table 2. Calculation for the ecological footprint in square metres per capita due to the Swiss food consumption in 1997 (Schweizerischer Bauernverband 1999, Wackernagel et al. 2000a).

EXAMPLE: ECOLOGICAL FOOTPRINTS FROM SWISS FOOD CONSUMPTION (continued)

CATEGORIES	Units	AMOUNT per year	I) FOSSIL ENERGY	II) ARABLE LAND	III) PASTURE	IV) FOREST	V) BUILT-UP LAND	VI) SEA
1.-FOOD								
.Veggies, potatoes & fruit	[kg]	242.0	375	254				
.Bread	[kg]	11.7	45	33				
.Rice, cereals, noodles, etc.	[kg]	75.7	235	287				
.Beans	[kg]	0.0	0	0				
.Milk & yogurt	[l]	116.1	180		2'795			
.Ice cream, sour cream	[l]	9.2	53		1'107			
.Cheese, butter	[kg]	21.8	220		5'247			
.Eggs [assumed to be 50 g each]	[number]	276.0	53	175				
.*Meat*								
..Pork	[kg]	23.6	366	205				
..Chicken, turkey	[kg]	10.7	133	110				
..Beef (grain fed)	[kg]	3.5	70	148	842			
..Beef (pasture fed)	[kg]	12.4	250		4'263			
.Fish	[kg]	7.4	172					3'721
.Juice & wine	[l]	98.6	382	244				
.Sugar	[kg]	44.7	111	87				
.*Vegetable oil & fat*								
..solid	[kg]	21.6	97	617				
..liquid	[l]	0.0	0	0				
.Tea & coffee	[kg]	8.7	101	164				
.Garden [area used for food]	[m2]	0.0		0				
.Eating out [complete meals]	[number]	0.0	0	0	0			
SUB-TOTAL-1			**2'843**	**2'323**	**14'254**	**0**	**0**	**3'721**

CATEGORIES	I) FOSSIL ENERGY LD.	II) ARABLE LAND	III) PASTURE	IV) FOREST	V) BUILT-UP LAND	VI) SEA	TOTAL
1.-FOOD	5'390	6'754	9'555	0	0	1'203	**22'902**

The main weakness of the EF methodology is the exclusion of emissions of toxic substances, such as heavy metals, which are not covered because it is assumed that these substances are accumulated and not biodegradable. In addition, the methodology was not developed for a detailed comparison of single products.

6. Material Intensity per Service Unit (MIPS) or Ecological Rucksack (ER)

Introduction

The calculation of the material intensity per service unit (MIPS) aims to analyse the total weight of resources extracted and materials moved due to human activities during the life cycle of a product or service. Service means the utility of function that can be obtained from a product. The ecological rucksack (ER) is the part of the material input that does not enter the product itself. The methodology is concerned with displaced environmental impacts, which often occur outside the consuming country. The material

23. See OECD, 1997 for an additional discussion of the assumptions and policy utility of the Ecological Footprint concept.

intensity per service unit of e.g. a package of biscuits includes the weight of its constituent materials (sugar, flour, plastic, paper, etc.) plus the weight of e.g. soil, rock, water and overburdens (re)moved during the extraction and processing of those materials. The methodology has been developed at the Wuppertal-Institute, Germany (SCHMIDT-BLEEK ET. AL. 1996).

Life cycle stages and emissions investigated, indicators and aggregation principles

Different material flows by weight are investigated from cradle to grave of a product or service. Material inputs are accounted for in five separate subcategories: abiotic raw materials (minerals, fossil energy carriers, etc.), biotic raw materials (biomass), moved soil, water (fresh-, ground-, process-water), and air (oxygen for combustion processes).

It is assumed that the reduction of input flow in general is associated with drastically reduced wastes and emissions. However, there is no specific procedure to characterise the environmental relevance for different types of material flows. Different mineral resources, for example, are added up without taking into account their scarcity. Emissions are not accounted for.

A key indicator used in ER analysis is total material consumption (TMC) per capita. It describes the per capita material flows caused by economic activities of a given region, within and beyond that region.

Data requirements and availability

There is no published background database, which could be used for independent analyses. Most of the case studies are based on information from the Wuppertal-Institute in Germany. It is difficult to assess the data availability for other countries.[24]

Case studies on food consumption

LOSKE & BLEISCHWITZ (1996) investigated the material intensities due to food consumption in Germany. They calculated the intensities for different product groups like milk, vegetables, etc.. Meat products show the highest intensities (>17 kg of masses moved per kg product) followed by sugar and fats. Vegetable, fruits, fish and pulps show relatively low intensities (< 2 kg/kg). Food consumption is responsible for about 20% of the TMC of households.

Summary of strengths and weaknesses and utility for policy making

Ecological rucksacks take a technical standpoint, focusing on the need to monitor and reduce the volume of material flows by means of eco-efficient measures (particularly dematerialisation and materials reuse) and lifestyle change (OECD 1997). The methodology gives an insight into the masses moved due to current consumption patterns. Because mass is an indicator that is easy to understand the MIPS concept is helpful for raising awareness of the need to change our lifestyles. The indicator MIPS, which aggregates mass and energy, can also be used as a proxy measurement if decision-makers accept the underlying assumptions (Table 3).

[24] See "Modelling a Socially and Environmentally Sustainable European Union" for calculations for Europe on http://www.wupperinst.org/Projekte/SuE/HTMLtexts/Pages/finalrep.html.

Table 3 Material intensity for different groups of food products consumed in Switzerland in 1995 (Jungbluth 2000:52, Loske & Bleischwitz 1996:104)

EXAMPLE: MATERIAL INTENSITY PER SERVICE

Table 3 shows a calculation for the MIPS related to food consumption patterns in Switzerland investigated for (JUNGBLUTH 2000:52, LOSKE & BLEISCHWITZ . Meat, milk and sugar are most important product groups with regard to the masses

Product Group	Food consumption (kg) per capita	MIPS (kg/kg)	MIPS (kg/year/capita)	Share of product group for total MIPS of food consumption
Milk	148.7	6.6	981	27.5%
Vegetables	89.1	1.4	125	3.5%
Grain	74.8	3.7	277	7.8%
Meat	57.6	16.7	962	26.9%
Vegetables	99.2	1.4	139	3.9%
Potatoes	46.6	2.0	93	2.6%
Sugar	46.8	13.1	613	17.2%
Vegetable oils and fats	13.5	12.1	163	4.6%
Eggs	10.2	4.2	43	1.2%
Fish, etc.	7.5	1.3	10	0.3%
Animal fats and oils	8.5	16.7	142	4.0%
Legumes	11.2	2.0	22	0.6%
Total food consumption	**613.7**	**5.8**	**3570**	**100%**

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A major weak point of the MIPS methodology is the aggregation of different kinds of resource uses and material flows without a weighting system linked to their environmental relevance. Furthermore, inputs from nature are considered but not outputs. The methodology provides a clear result irrespective of the value judgement of the decision-makers and stakeholders due to the prescribed weighting procedure, which cannot be modified by the decision-maker. Finally, looking only at the weight of material used is not appropriate for the discussion of some environmental impacts (e.g. toxicity or biodiversity) in detail. There are only few case studies from other organisations than the Wuppertal-Institute due to the limited availability of a common database.

7. Material-Flux Analysis (MFA)

Introduction

Material-flux analysis (MFA) investigates the flows of so-called indicator elements (e.g. phosphor, carbon, water) or the energy use within a geographical or functional system. The MFA has been developed to understand the metabolism of the anthroposphere. All inputs to and outputs from a system are accounted for. MFA for household consumption distinguishes between different activities such as nutrition, housing, mobility, etc. An overview for different working groups (from Austria, Germany, Switzerland and in other countries) has been elaborated in the European project CONACCOUNT.[25]

Life cycle stages and emissions investigated, indicators and aggregation principles

Some studies investigate all parts of the life cycle for the products that are inputs to outputs from the system investigated, while others account only the direct inputs and outputs of substances. Only those

[25] See http://www.wupperinst.org/Projekte/ConAccount/index.html.

products with an important flow of the materials investigated are considered. Indicator elements used by MFA are for example carbon, sulphur, water or metals. All chemical compounds of these elements are summed up. Some studies also investigate energy flows similar to the CERA. The indicator elements represent resources or chemical elements that are considered to be important for certain environmental impacts. There is no weighting scheme to outline the overall environmental importance of the different chemical compounds of an element (e.g. CO_2, CH_4 and phenol emissions to water are summarised by their carbon content) or to summarise all elements to one indicator.

Data requirements and availability

Data stem from the investigation of production facilities, material accounts of a company as well as national or regional statistics of e.g. food or energy consumption. Depending on the scope of investigation the data requirement might be high. There are no background databases developed for the use in MFA.

Case studies on food consumption

BACCINI *et al.* (1993) analysed the material fluxes through the households of a city. Nourishing was one of the specific activities investigated and includes all preceding stages of food production, but not e.g. cooking (which falls under housing) or toilet effluents (cleaning). Food consumption is mainly responsible for phosphor fluxes in a city. Chlorine and sulphur flows are also dominated by the nutrition-related activities.

Summary of strengths and weaknesses and utility for policy making

The MFA is valuable for understanding the mechanisms of certain substance flows in a system. It helps to identify the main sources or contributing processes for the emissions of elements that are known to contribute to an environmental problem in the system investigated. Scenarios of technical changes can be modelled by MFA. The methodology helps policy-makers to identify key points or options in a system where the flows of substances can be influenced. It is flexible, because important elements are defined on a case-to-case basis. An extension of economic aspects allows a modelling of impacts due to political measures, such as energy taxes.

To date there is no valuation methodology to highlight and compare the environmental relevance of different chemical compounds investigated in an MFA. Generally, the results are only applicable to the particular analysis and problem at hand.

8. Transport related methods

Introduction

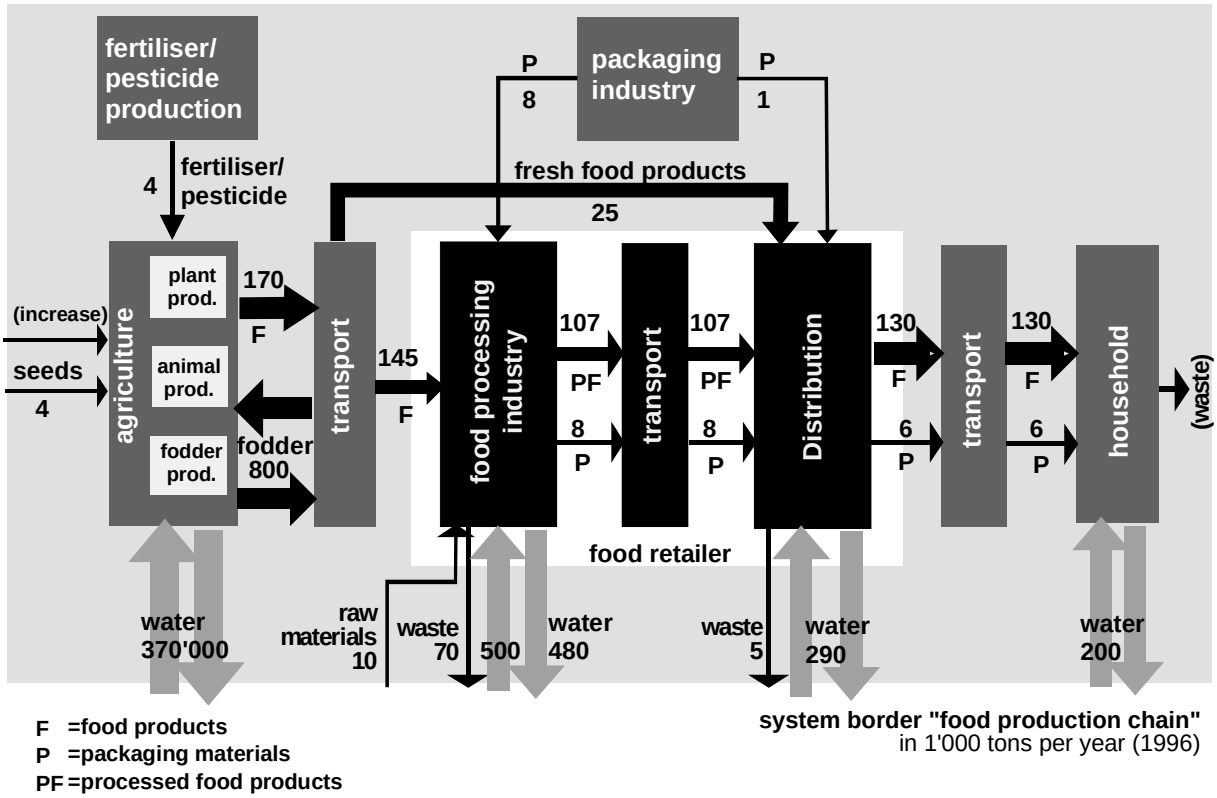
Transport related to food products is known to contribute to certain environmental problems including energy use, CO_2 emissions and noise. Freight transport has increased due to globalisation and the economic optimisation of production processes and has been an issue of political debate. Calls for regionalism are one of the answers to address traffic-related environmental problems.

Different methodologies exist that aim to analyse the transport trends related to the production of consumer products like food. BÖGE (1995) investigated the total kilometres that the different ingredients of strawberry yoghurt travelled until the product reached the consumer's shopping basket. CARLSSON (1997) proposed a methodology to calculate a weighted average source point or distance (WASP/WASD) for the origin of products consumed in one country. To date there is no common method for investigating transport-related environmental impacts.

Fig. 4 Current material fluxes in the food production chain of a Swiss retailer. The size of most arrows is proportional to the magnitude of the mass flows that they represent. Exceptions are made for the flows of water and fodder, because these flows are too large. The flow of waste from households is not assessed (Faist et al. 1999b).

EXAMPLE: MATERIAL-FLUX ANALYSIS

FAIST *et al.* (1999a, 1999b) investigated the material flows linked to the activities of a food retail centre in Switzerland. Figure 4 shows an example from this research work. The largest turnover of materials occurs in agriculture and is mainly caused by meat and dairy production. 800'000 tons of fodder are needed to produce 170'000 tons of milk, animals and other food products. The analysis shows an equal distribution of energy requirements in agriculture, households and for intermediate processes (transports, processing, retailing). A change in consumption patterns could influence the energy efficiency (energy use in comparison to consumption of nutritional energy). Retailers should consider the whole food chain and not solely the energy uses within their own facilities. The MFA shows the dominance of phosphorous, nitrogen, water and land due to the food consumption of households (FAIST *et al.* 1999b).



Life cycle stages and emissions investigated, indicators and aggregation principles

BÖGE (1995) investigated all phases of transport of the product and intermediate products while CARLSSON (1997) accounts for the transport from producer to consumer for both Swedish produced and imported products. The total kilometres travelled or the tonne-kilometres for a certain product or consumption pattern serve as indicators. The environmental impacts of the different transport modes have not been investigated so far.

Data requirements and availability

Although the scope of transport-related analysis is limited, data are not easy to come by. Normally, producers of a product know the origin of the intermediate products they buy directly, but they know little about the transport that took place further upstream. It is also difficult to estimate average figures for a product that can reach the consumer via different routes.

Case studies on food consumption

The methodology has mainly been used for food products (BÖGE 1995, CARLSSON 1997). The case studies show that even common products like yoghurt are linked with lengthy transport prior to reaching the consumer due to the delivery of ingredients, packaging materials, etc. to the manufacturer (BÖGE 1995).

EXAMPLE: TRANSPORT-RELATED MESURES

CARLSSON-KANYAMA (1999) investigated transport linked to Swedish consumption patterns of carrots and tomatoes in detail. The average distances (WASD) from the producer to the consumer of carrots and tomatoes were 320km and 1340km, respectively. An analysis for the time period 1965 to 1992 revealed a distancing of the WASP of grapes from northern Algeria to Mauritania. The methodology not only allows analysts to calculate point of origin, but also to estimate the average point of food consumption. For Sweden this has been located at 59° 2' N and 15° 11' E, close to a town called Svennevad (CARLSSON-KANYAMA 1999:14-15).

Summary of strengths and weaknesses and utility for policy making

The investigation of transport related to the consumption of a certain food product provides useful information. Calculation of WASD and WASP allows a direct comparison of consumption patterns and their development over time. The investigation of transport kilometres is valuable when related to a clear analytical scope on transport related environmental impacts. The methodology provides information about some of the associated impacts of globalisation.

A weak point of this type of analysis is that environmental impacts of different modes of transportation vary considerably. Thus, for example, a tonne-kilometre travelled by ship is not comparable with the impacts of a tonne-kilometre travelled by airplane.

A detailed comparison of regional products with products from a global production scheme in an LCA shows that the regional products are not automatically less environmental polluting than their globally-sourced products due to different production conditions and the distinct impacts of different modes of transportation. Longer transportation distances could reduce total environmental impacts if it means that greenhouse production can be avoided. The investigation shows that the environmental impacts or food products should be investigated over the full live cycle (PROBST 1998). A policy discussion that focuses on uniquely transport effects could lead to a biased picture on how best to reduce overall environmental impacts of any particular product.

ANNEX 3 INDICATORS FOR MONITORING ENVIRONMENTALLY RELEVANT TRENDS OF FOOD CONSUMPTION

Production methods

1. Share and per capita availability of products from e.g. organic, integrated, conventional and greenhouse production

This indicator aims to measure shifts in agricultural production practice. It should cover indigenous products as well as imports. The higher the share of products from intensive production like greenhouses the higher the environmental impact. The indicator serves to monitor the success of political measures like labeling schemes or environmental subsidies for the agricultural sector. Agricultural and foreign trade statistics are the basis for this indicator. If data from foreign trade are not available with the necessary accuracy an extension of these statistics would be necessary. The average energy use or environmental impacts[26] for different production methods can be assessed with LCA, CERA, EF, or MIPS.

2. Share and per capita consumption of food products with different degrees of processing (fresh, chilled, conserved, deep-frozen, pre-prepared, ready made, self-service and restaurant)

This indicator aims to measure the shifts in consumption patterns towards more processed food products. A shift from fresh to conserved and pre-prepared products leads to a rise in energy use and environmental impacts. Statistics for per capita food availability and sales of food retailers and restaurants should serve as a basis for the calculation of this indicator. The environmental impacts due to the shift in processing methods can be assessed with CERA, HA, LCA, EF, or MIPS.

3. Total energy use per capita and the share of different economic sectors (chemical industry, agriculture, food industry, retailers, restaurant, freight carriers, households) for meeting food demand

In countries with a good database for input-output statistics this indicator would more directly monitor the environmental impact linked to developments in different stages of processing. It would also help to identify the overall importance of different stages in the life cycle of food products. Consumption statistics and IOA or HA can be used to indicate the energy use and greenhouse gas emissions.

4. Percentage of actors in the food chain that have implemented an environmental auditing or management scheme for their company

An environmental audit helps to identify possibilities for the reduction of environmental impacts. This indicator might also be considered in an indicator set for different industries, as it is not directly

[26] "Environmental impacts" refer to the indicator used by the different methodologies such as greenhouse gas emissions, Eco-indicator 95, material intensity or ecological footprint.

related to food consumption patterns. Statistics for certified companies are the basis for this indicator[27] but it is not yet possible to quantify the environmental impacts.

5. Food products produced with genetically modified organisms

The use of genetically modified organisms in agriculture is a theme of critical debate. Today it is difficult to assess the environmental impacts due of increased use of these organisms and it is unclear how to weight negative or positive aspects (Some case studies have dealt with this issue, e.g. JANK *et al.* 1999, KLOEPFFER *et al.* 1999, RENNER *et al.* 1998). The share of genetically modified organisms in agriculture should be monitored with data from seed producers or agricultural statistics. It is not possible to quantify the environmental impacts.

Transportation

6. Per capita average distance and mode of transportation for domestic food transports

This indicator should measure the domestic transport of food products. A shift from train to road and air based transports and a rise in total transports for food products per capita indicate a rise in environmental impacts. The success of policy measures like energy taxes or reduction of subventions (e.g. for road transports) can be monitored directly with this indicator. Average transport distances can be investigated with national transport statistics using WASD. The average energy uses or environmental impacts for different transport modes can be assessed with LCA or CERA. LCA data can be found e.g. in (MAIBACH *et al.* 1995).

7. Per capita average transport distance and transport modes of imported food products

This indicator should measure the impacts due to transports of imported food products. A shift from train to road and air based transports and a rise in total transports for food products per capita indicate a rise in environmental impacts. The indicator helps to identify environmental impacts due to globalization and diversification of consumption patterns. Average transport distances could be investigated with national foreign trade statistics using WASD. The average energy uses or environmental impacts for different transport modes can be investigated with LCA or CERA.

Indicators 6 and 7 should be summed together for cross-country comparisons of the impacts of household food consumption patterns. In small countries the impacts due to imports are higher while in large countries domestic transport is important.

Purchasing

8. Share of different eco-labels for food products sold in a country

Eco-labels help consumers to buy less environmentally harmful products. Information about the sales share of different labels helps to measure the acceptance of these labels. Only labels with widely accepted guidelines that show a considerable improvement in comparison to conventional production (such as Bio-Suisse (CH), Demeter (D) or KVAG (S)) should be considered for this indicator. Statistical data can be gained from sales statistics of food retailers and the label organizations. It is not possible to quantify the environmental impacts.

[27] Statistics can be found on e.g. http://www.iso14000.com/, http://www.iwoe.unisg.ch/index-d.htm or http://www.diht.de/flash.html.

9. Types of food distribution (direct on farm, market, small shop, supermarket, fast-food, restaurants, etc.)

The share and frequency of visiting different types of food dealers indicates environmental impacts from e.g. personal transport, land use and construction of buildings. Large supermarkets as well as farms that sell their products directly are often accessible only by private cars. A high share of supermarkets indicates a dispersal of areas for living, shopping and working. This leads to increased environmental impacts due to transports and land use. Statistical data for the earnings of different types of distributors can be found in economic databases. It is not possible to quantify the environmental impacts.

Consumption level

10. Per capita food availability (kg or MJ nutrition value per head) and share of different product categories (meat, vegetables, grains, fats, beverages, etc.) in food consumption

The availability (production + imports - exports) of food differs from country to country. If food availability is higher than actual demand this leads to food wastes, to over consumption or to long time storage (e.g. of butter). Over consumption leads to negative health effects while wastage and storage cause unnecessary environmental impacts. This indicator serves to compare the level of food availability and consumption in different countries. As environmental impacts vary among different product groups this indicator can also analyze environmental impacts due to changing consumption patterns, e.g. a rising share of meat products. Statistical data may be available from foreign trade, agricultural and consumption statistics. The average environmental impacts for different product groups can be investigated with HA, CERA, LCA, EF, or MIPS.

11. Food availability against food consumption as an indicator for wastage or per capita food waste from waste statistics

It is possible to assess the share of non-consumed products (food waste) directly if data for food availability (from agricultural and foreign trade statistics) as well as for food consumption (nutrition studies) are available. The amount of food waste might also be investigated from national waste statistics. The edible parts should be differentiated according to disposal method (incineration, deposition, composting, etc.). The average environmental impacts for the products and the waste management can be investigated with LCA, EF, MIPS or HA.

Household behaviour

12. Per capita packaging wastes, recycling quotas and means of waste treatment for different materials like glass, paper, metals or plastics

The amount and type of packaging wastes from food products and their disposal way is one indicator to assess the environmental impacts due to packaging. A rise in packaging wastes per capita indicates higher environmental impacts while an increased share of recycled wastes indicates an environmental improvement. Data can be gained from national waste and recycling statistics. It is difficult to quantify the environmental impacts, but might be possible with LCA for package materials (e.g. HABERSATTER *et al.* 1998) and for waste management (e.g. ZIMMERMANN *et al.* 1996).

13. Mobility for home transport

The share of different transport modes (foot, bike, public transport, car), while buying (food) products, indicates the environmental impact due to home transports. A rising share of private cars indicates rising impacts due to fuel use, noise and land occupation for streets, etc.. Data can be found in transport statistics for the share and distances of different transport modes while purchasing goods. The average environmental impacts for different transport modes can be assessed with LCA or CERA. LCA data can be found e.g. in (MAIBACH *et al.* 1995).

14. Distribution and energy use of household appliances for food storage and preparation

The number and size of household appliances for food storage and preparation (stoves, freezer, deep-freezer, and small appliances for food preparation) indicates the direct energy use in the household. Data for kitchen equipment can be found in household statistics. The average energy use due to the use of white goods can be assessed with CERA. Hybrid-analysis might be used to assess the impacts due to the production of different white goods. LCA data for supplying and using electricity, gas and wood can be found in (FRISCHKNECHT *et al.* 1996, JUNGBLUTH 1997).

Non-quantifiable key issues

There are other important aspects linked to food production and consumption patterns that today are difficult to cover or compare with quantitative indicators. Some of these key issues are described in the following chapter. They should be kept in mind even if they are difficult to quantify and monitor.

Toxic emissions from food processing

Some toxic emissions occur only in specific sectors of food industries: example n-hexane from soybean oil mills, toxic substances from frozen and canned food processors, ammonia used for citrus plantation, acetaldehyde used as a component of food flavouring (KAUFFMAN & CHEVROT 2000) or ethanol formed during bread baking (JEDVALL 2000). It is difficult to monitor the environmental impacts of these emissions with general indicators. Different emissions could be reported for certain food industries. The use of an IOA could be a tool in countries where the data exists to calculate emissions and related environmental impacts linked to consumption patterns for processed food products.

Use of water resources

From a global perspective water as a scarce resource will be the limiting factor for food production in some areas in the near future (ZEHNDER 1999). The impacts due to the use of water resources vary from country to country and would require monitoring the availability and the use of water resources in different countries with data from meteorological statistics, although it is in some cases difficult to quantify and compare the environmental impact. Most of OECD countries do not directly suffer from water scarcity, but through their imports of agricultural products they do influence water availability in other countries, i.e. in the Near East.

Initiatives by non-governmental organizations, private sector and governments

Different actors influence consumption patterns and developments in the food production chain. Some of these organisations (e.g. Ecoteam, Global Action Plan (GAP) or World Wide Found for Nature (WWF)) try to influence behaviour in the field of food consumption directly. Others, e.g. co-operation of actors in the food chain, can influence production patterns. The activity of such organisations and actors

should be monitored within the OECD programme even if it is not possible to describe the success directly with environmental indicators.

Public knowledge about environmental impacts of food consumption

The knowledge about environmental impacts of food consumption is a prerequisite for environmentally sound behavior. In Switzerland certain targets for public knowledge have been established within the action plan "Health and Environment" (e.g. BIRCHER *et al.* 2000, KAHLMEIER 1998). It is planned to frequently monitor different indicators that describe public knowledge in Switzerland. One target is for example "By 2002 80% of the population will know what is healthy and seasonal food." It might be considered to use this list of goals and questionnaires developed for Switzerland also within other OECD countries.

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