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Chapter 1 Pathways towards Sustainable Food Consumption Patterns

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1 Introduction

The Oslo Declaration on Sustainable Consumption (Tukker at al., 2006) has stated that sustainable consumption focuses on strategies for the highest quality of life, the efficient use of natural resources, the effective satisfaction of human needs, and equitable social development. Sofar, research on sustainable food consumption has focused on energy use, generating knowledge on energy requirements for individual foods, meals, and food consumption patterns (e.g. Vringer and Blok, 1995; Carlsson-Kanyama, 1998; Gerbens-Leenes, 1999; Gerbens-Leenes, 2000; Kramer, 2000; Kok et al., 2001). Those studies have shown that in the western world, large energy reductions are possible. Understanding the food consumption-environment relationship, however, requires more insight into the different dimensions of sustainability. This study proposes the adoption of three sustainability indicators, land, fresh water, and energy use, indicators that take the main functions of the environment into account and address global sustainability issues.

Resource use for per capita food consumption is determined by the amounts and types of foods that are consumed, i.e. food consumption patterns, and by specific resource requirements per food item. The total use of natural resources for food consumption depends on the combined effect of a production and a consumption subsystem. The aim of the study presented here was to indicate transition pathways towards more sustainable food consumption patterns. This is done by assessing land, water, and energy requirements for a food consumption pattern from a developed country, the Netherlands, and by identifying long-term trends. This information provides insight into desirable directions of change. In this way, the study contributes to a better understanding of the food consumption-environment connection, and provides practical information for pathways towards sustainable food consumption patterns.

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2 Food systems

Food systems include two subsystems: (i) a consumption subsystem and (ii) a production subsystem. Total food consumption is determined by the size of a population and amounts and types of foods consumed, i.e. food consumption patterns. The production subsystem comprises primary and secondary production, as well as the food industry. Primary production grows agricultural crops. Yields per hectare depend heavily on the type of system applied, leading to large variation. Crops from the primary production systems, such as soybeans, barley, or maize, form the basis for the secondary or livestock production. Resource requirements for single food items can differ considerably. The total use of natural resources for a specific food consumption pattern depends on the combined effect of its production and consumption subsystem. This means that fruitful research on requirements of consumption for natural resources can only be carried out for a clearly defined production subsystem.

3 Data and methods

3.1 Requirements of food for natural resources in the Netherlands

For the identification of pathways towards sustainable food consumption patterns, this paper adopted the three core indicators land, water and energy from Gerbens-Leenes et al. (2003). By combining information on resource use for food items with data on per capita consumption, results show requirements of consumption patterns for natural resources. Data on resource requirements per unit of food is available for the Dutch production system in 1990 (Gerbens-Leenes, 2006; Kramer and Moll, 1995). The study assessed the use of land, 'transpirational' water, and energy for an affluent food consumption pattern, the Dutch pattern of 1990, and made time trends for this pattern over the period 1950-1990. For land and water, the study combined data on supply (kg per capita per year) from the FAO (2006) with data on land and 'transpirational' water requirements per unit of food from Gerbens-Leenes (2006). The calculations were done for seventeen foods from five food categories: (i) *beverages* (beer, wine, coffee, and tea); (ii) *fats* (vegetal oil); (iii) *meat* (beef, pork, and poultry); (iv) *dairy and eggs (*raw milk, butter, cheese and eggs); and (v) cereals, sugar, potatoes, vegetables and fruits. In an earlier study, Kramer (2000) showed that energy is needed in all chain links of a food production system. For the assessment of energy requirements, therefore, more detailed information on final consumption was needed. Information on household consumption (kg per household per year) for over a hundred food items was obtained from the study of Gerbens-Leenes (1999) and combined with data on energy requirements from Kramer and Moll (1995).

3.2 Long-term trends in actual land, water and energy requirements

The comparison of long-term trends using data from the 1990 production system provided information on the impact of changes in consumption on the *relative* use of natural resources. Over this period, though, both the consumption and the production subsystem were changing. For example, agriculture generated larger output per unit of land. Beside an assessment of *relative* resource requirements, this study also made an estimation of developments of *actual* requirements. For land, it estimated actual requirements by using the increasing yield levels of wheat as an indicator. It multiplied 1990 land requirements by the ratio of actual and 1990 land requirements (m^2 kg^{-1}). For 'transpirational' water, changes in the biophysical production subsystem do not affect water requirements per unit of food because 'transpirational' water requirements are constant per unit of output (Gerbens-Leenes and Nonhebel, 2004). For energy, historic data on requirements for individual foods (MJ kg^{-1}) are lacking, but information on total, per capita energy requirements over the period 1950-1990 is available from Vringer and Blok (1995). For energy, the study first calculated time trends related to changes of annual, per capita supply using data of the production system of 1990 as input, providing relative results. Next, it evaluated the gap between relative energy requirements for per capita food supply and actual energy requirements for total, per capita food consumption.

4 Results and discussion

4.1 Land use in 1990 and developments for the Dutch food consumption pattern 1950-1990

Figure 1 shows land requirements for Dutch food supply in 1990. The categories of meat, and dairy and eggs, needed 50 percent of total land requirements. For the category of fats, requirements were relatively large, about one fifth of total requirements. For cereals, sugar, potatoes, vegetables, and fruits, requirements were in the same order of magnitude than for beverages, about 14 percent.

Figure 2 shows long-term trends for land requirements over the period 1950-1990. The total requirement results from the combined effect of the consumption and the production subsystem. Consumption changed towards increased per capita supply of more and more affluent foods. The bottom line in Figure 2 shows the impact of these changes on land requirements. If food had been derived from the Dutch production subsystem as it existed in 1990, changes in per capita supply would have caused an increase of relative land requirements of 40 percent, an increase that mainly resulted from larger per capita supply of beverages and meat. However, over the period considered, also changes in the production subsystem occurred resulting in decreasing, actual land requirements per unit of food. This is illustrated in Figure 2 by the decreasing land requirement for wheat. The upper line shows that between 1950 and 1990 land requirements for wheat (m^2 kg^{-1}) more than halved. The development of actual land requirements is a combined effect of increased per capita supply of more and more affluent foods and larger output per unit of land in agriculture. The middle line in Figure 3 shows the actual development. Over the period 1950-1990, the combination of changes in the consumption and the production subsystem caused a decrease of actual, per capita land requirements by 40 percent.

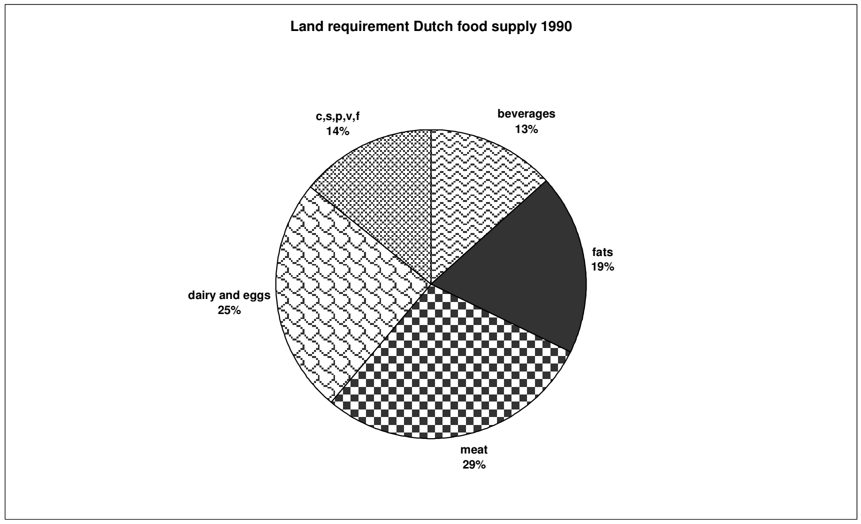

Figure 1: Land requirements for the five food categories of the Dutch 1990 food supply, beverages; fats; meat; dairy and eggs; and cereals, sugar, potatoes, vegetables, and fruits (c,s,p,v,f)

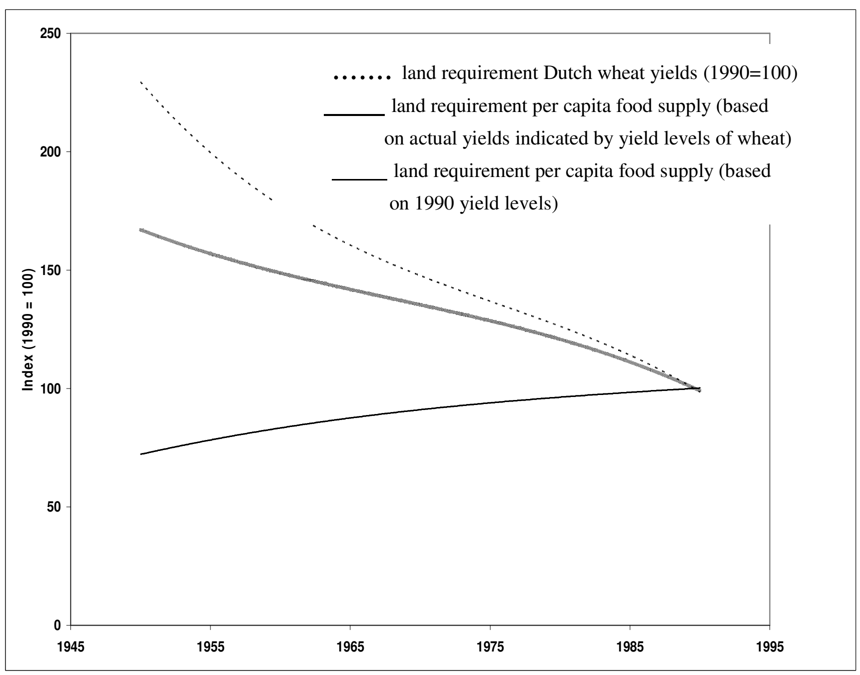

Figure 2: Long-term trends for land requirements for Dutch food supply over the period 1950-1990. The upper line illustrates decreasing, actual land requirements by the decreasing land requirement for wheat. The bottom line shows changes in land requirements due to changes in food consumption patterns using data from the Dutch production subsystem in 1990. The middle line shows the combination of changes in the consumption and the production subsystem

4.2 'Transpirational' water use in 1990 and developments for the Dutch food consumption patterns 1950-1990

Figure 3 shows results of 'transpirational' water for Dutch food supply in 1990. For the category of meat, and dairy and eggs, requirements were relatively large. These two food categories needed almost 70 percent of total 'transpirational' water requirements. For the category of cereals, sugar, potatoes, vegetables, and fruits, 'transpirational' water requirements were about 20 percent. In this category, only two food items accounted for 80 percent of all 'transpirational' water requirements, fruits (41 percent) and cereals (40 percent). The categories of beverages and fats showed the smallest requirements for 'transpirational' water.

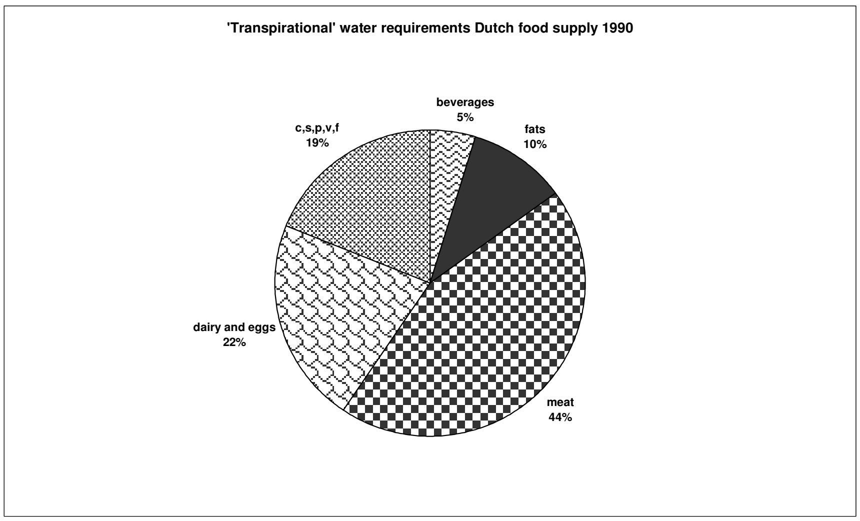

Figure 3: 'Transpirational' water requirements for the five food categories of the Dutch 1990 food supply, beverages; fats; meat; dairy and eggs; and cereals, sugar, potatoes, vegetables, and fruits (c,s,p,v,f).

Figure 4 shows 'transpirational' water requirements for Dutch per capita food supply over the period 1950-1990. Changes in consumption resulted in an increase of requirements by 45 percent. Requirements for the food category of dairy and eggs remained stable, while requirements for the other food categories increased.

4.3 Energy use in 1990 and developments for the Dutch food consumption pattern 1950-1990

Figure 5 shows energy requirements of Dutch household food consumption in 1990. For the category of meat, and dairy and eggs, requirements for were relatively large. Almost half of total energy requirements were needed for these two food categories. For the category of cereals, sugar, potatoes, vegetables, and fruits, energy requirements were about 40 percent of the total. The relatively large energy requirement was caused by energy use in the food chain, such as energy for transportation, production of fruits and vegetables in greenhouses, and industrial manufacture. The fraction of energy needed for beverages was 12 percent, the fraction of energy needed for fats was much smaller.

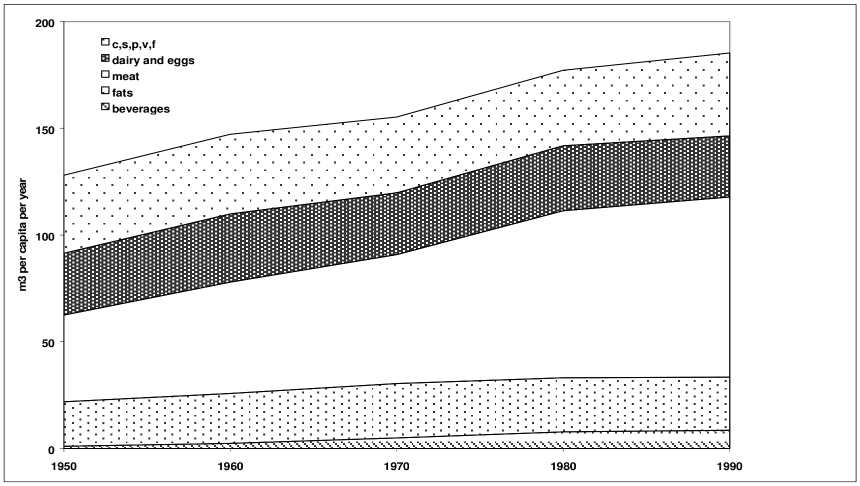

Figure 4: Long-term trends for 'transpirational' water requirements for the five food categories of the Dutch food supply, beverages; fats; meat; dairy and eggs; and cereals, sugar, potatoes, vegetables, and fruits (c,s,p,v,f) over the period 1950-1990.

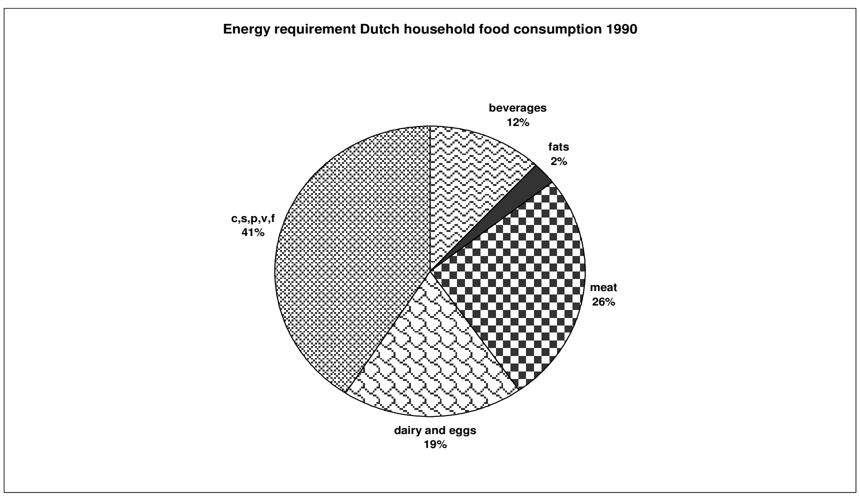

Figure 5: Energy requirements for the five food categories of the Dutch 1990 household comsumption, beverages; fats; meat; dairy and eggs; and cereals, sugar, potatoes, vegetables, and fruits (c,s,p,v,f)

Figure 6 shows trends in relative, per capita energy requirements for supply for the five food categories, as well as actual, total, energy requirements for final, per capita consumption over the period 1950-1990. Over the period 1950-1990, per capita energy requirements for supply increased by 60 percent. The main changes occurred for the categories of beverages, fats, and for the category of meat. For beverages, the increase of requirements was caused by larger consumption of coffee, wine and beer. In the category of meat, the increase was mainly caused by larger consumption of poultry and pork. Figure 6 also shows that, during the forty-year-period, actual, per capita energy requirements increased even more, by 83 percent (+10 GJ per capita per year), causing a widening of the gap between energy requirements related to supply and to final consumption. The increase of this gap is understandable by assuming that more and more energy is needed in links of the food chain, for example, in agriculture, where increasing energy inputs caused an increase of yield levels, for food conservation (e.g. cooling and freezing), and transportation.

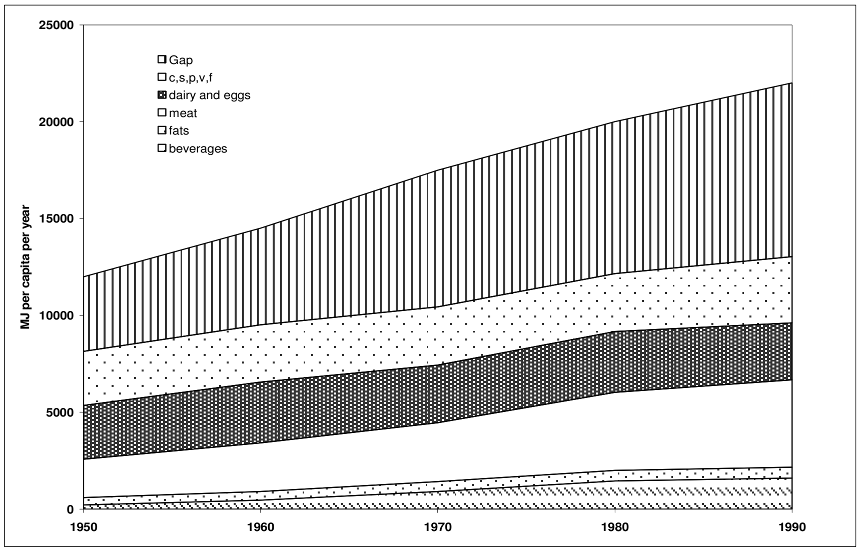

Figure 6: Long-term trends for energy for the five food categories of the Dutch food consumption pattern, beverages; fats; meat; dairy and eggs; and cereals, sugar, potatoes, vegetables, and fruits (c,s,p,v,f). of the Dutch food consumption pattern over the period 1950-1990. The figure shows per capita energy requirements for food supply based on 1990 data for the five food categories, as well as actual, total energy requirements for per capita food consumption

4.4 Comparison of natural resources

When the three resources were compared, the actual trend for land offsets trends for water and energy. Where land requirements decreased by 40 percent, ‘transpirational’ water requirements increased by 45 percent, and energy requirements almost doubled. For all resources, the effect of consumption changes were mainly related to changes in the food categories of beverages (wine, beer, coffee), meat (beef, pork, poultry), and fats. For water, larger consumption of fruits caused an additional increase of requirements for the category of cereals, potatoes, vegetables and fruits.

4.5 Pathways towards sustainable food consumption patterns

The identification of the impact of different food items and food categories on the use of land, transpirational water, and energy provides a tool to identify and develop pathways towards more sustainable food consumption patterns. Food items with similar functions can differ in their resource requirements. Substitution of foods with smaller resource requirements, therefore, is an option for reduction. Options to reduce the use of energy have been elaborated in depth in Kramer (2000). This study, therefore, focused on land and water use. Options for resource reduction are:

► **Beverages:** substitution of coffee by tea, or wine by beer.

► **Fats:** to reduce land requirements, the substitution of soyoil, a basic ingredient of vegetal oils and margarines, by rape or sunflower oil. For water, sufficient data were not available.

► **Meat:** requirements for land, energy and transpirational water decrease in the following order: beef, pork, poultry.

► **Dairy and eggs:** there are no options for reduction of resource use by substitution because requirements for milk and eggs are in the same order of magnitude.

► **Cereals, potatoes, vegetables, and fruits:** differences in land requirements occur. French beans, for example, have 50 percent larger land requirements than carrots. Substitution of vegetables or fruits with relatively large land requirements by foods showing lower requirements, however, is not in line with nutritional constraints that promotes a high diversity of consumption (Whitney and Rolfes, 1999). Staples have decreasing requirements in the following order: rice, pasta and potatoes providing options for reduction.

For food items from different categories, the substitution of food items from the category of meat, and dairy and eggs by high protein foods from the category of cereals, sugar, vegetables, potatoes and fruits, such as peas, cause a substantial reduction of the use of land as well as water.

5 Overall conclusions

Specific resource requirements for foods vary, leading to variation of resource requirements among food consumption patterns. For the affluent Dutch pattern of 1990, the category of animal foods (meat, and dairy and eggs) required 66 percent of total transpirational water, 54 percent of agricultural land, and 45 percent of energy requirements. Beverages and fats required relatively large amounts of land, but less water and even less energy. The food category of cereals, potatoes vegetables and fruits required relatively large amounts of energy, about 40 percent, which can be attributed to energy needed in chains, such as for the manufacture, transportation and conservation of foods. Long term trends for the Netherlands showed that the pressure of consumption on land, water and energy has increased substantially over a forty year period. Especially increased consumption in the food category of meat caused large changes in land, transpirational water, and energy requirements, additional effects were caused by increased consumption of beverages. For energy, the increased energy use in chains was apparent.

Pathways towards more sustainable food consumption patterns include substitution of foods by foods with similar functions but lower requirements, for example, wine by beer; coffee by tea; soyoil by sunflower or rapeoil. In the category of meat, requirements decrease in the following order; beef, pork, poultry, in the category of cereals, potatoes, vegetables and fruits, requirements for staples decrease in the order of rice, pasta, potatoes. Substitution among food categories is possible for food items of the category of meat, and dairy and eggs by protein rich vegetal foods, such as peas. This option shows large resource reductions.

In the next ten years, a large share of the world population will adopt a more western lifestyle, including affluent food consumption patterns. For many people, this will improve the quality of their daily food and contribute to better health conditions. When, at the same time, limited land and water resources, and assimilate capacity of natural systems are respected, changing food consumption should move in the most sustainable direction. A better understanding of the food consumption-environment connection provides practical information for directions of change.

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