



ARTICLE

Developing and disseminating a foodprint tool to raise awareness about healthy and environmentally conscious food choices

Corné van Dooren¹ & Tine Bosschaert²

¹Netherlands Nutrition Centre, Eisenhowerlaan 108, The Hague 2508 CK The Netherlands (email: dooren@voedingscentrum.nl)

²Écolife, Valkerijgang 26, Leuven 3000 Belgium (email: tine.bosschaert@ecolife.be)

This article describes the development and dissemination of an ecological footprint tool that provides a concise and scientifically grounded summary of the environmental impact of personal food choices. Developed to be easy to use and available to consumers via online social networking platforms, the tool aims to raise awareness and to provide an impetus for behavior change. The foodprint tool communicates scientifically informed and customized practical advice on how individuals can reduce their ecological footprint (EF) (or “foodprint”). The first part of the article describes the process of developing this tool, the choice of indicator, the goals, and the results. Among other aspects, the tool enables users to understand that the largest contributors to their footprint are sources of animal protein: dairy, meat, and fish. The second part of the article describes the strategy guiding the tool's design and implementation, which is based on a combination of contextual communication, feedback from peers, and intrinsic motivation. In this footprint tool, a focus on food patterns, interactive feedback, and social media plays a key role. The tool consists of a survey with fifteen questions about personal food choice that allow users to receive individualized feedback, including five suggestions for reducing personal footprints. Users can also share their results through customary social media. Due to an effective outreach campaign, a total of 90,000 Dutch consumers used this tool over a period of four months, with 1% indicating that they intended to change behavior.

KEYWORDS: food preferences, diets, management tools, communication, social behavior, internet, environmental impact

Introduction

Geographical Boundaries of Food Production

In recent decades, researchers have proposed several indicators to characterize the environmental impact of cities, countries, and populations. Though already in use in the early 1920s, the concept of a foodshed (Hedden, 1929; Peters et al. 2009b), introduced to designate a rural territory structured around supplying a city with agricultural products, provides a useful framework for analyzing the local production capacity of individual cities (Peters et al. 2009a). European and North American cities and their surrounding areas are characterized by concentric rings of farming activity devoted to the city's food supply, beginning with market gardening and dairy farming, followed by forestry, cereal production, and finally cattle farming, as Von Thünen described in 1826 (Billen et al. 2012). These scientists developed various methods for mapping and assessing potential foodsheds, meaning land areas that could theoretically feed urban centers. The resultant approaches evaluated how the location of food production in relation to its consumption affected the environment and the vulnerability of the overall food

system (Peters et al. 2009b). In today's increasingly globalized world, the foodsheds of European and North American cities are coming under pressure, not least from conflicting land uses, such as suburbanization, leisure areas, and natural parks.

Recent years have seen the development of a number of indicators to assess the global scarcity of land, water, and energy. For instance, Wackernagel & Rees (1996) developed the now classic concept of the ecological footprint (EF) based on a comprehensive estimate of the total productive area required to sustainably produce the resources consumed by a city, given the current state of agricultural technology, as expressed in “global hectare equivalent” units. Hoekstra & Chapagain (2004) introduced a method for calculating water footprints, representing all direct and indirect water use associated with urban consumption of commodities. In turn, the carbon footprint (Wiedmann & Minx, 2008) quantifies the overall emission of greenhouse gases (GHGs) resulting from urban activities, while the nitrogen footprint (Leach et al. 2012) relates to the corresponding introduction of reactive nitrogen into the biosphere (Billen et al. 2012). In this study, we use the EF as a means

of representing the geographical and ecological boundaries of food production.

The Problem: Our Footprint Exceeds Available Biocapacity

The capacity of the Earth—our ecological system—is under pressure. There is strong scientific evidence that we have surpassed the limits of climate change and biodiversity and changes in land use are no longer within the boundaries of what is safe for the planet (Rockström et al. 2009). A large share of the human EF is attributable to our food production and approximately one third of the human impact on climate and land use is related to our diet and the food chain (Dutilh & Kramer, 2000; Tukker et al. 2006; Garnett, 2011). These effects are larger than the impacts of leisure, housing, and labor (Vringer et al. 2010). Climate change mitigation policies tend to focus on the energy sector, paying the livestock sector surprisingly little attention, despite the fact that the latter accounts for 18% of worldwide GHG emissions and 80% of total anthropogenic land use (Stehfest et al. 2009). The problem is that the per capita EF of food, or “foodprint,” in many developed countries, including the Netherlands, is higher than the world average and is higher than the foodprint technically available on a global scale. It is even higher than the total worldwide per capita available biological capacity for food, shelter, mobility, goods, and services combined (GFN, 2010).

The Footprint is Dominated by Personal Food Choices

The EF is largely determined by food consumption and personal dietary choices. The average per capita EF in the Netherlands is 6.1 global hectares (gha),¹ of which 34% can be attributed to the foodprint (2.1 gha). This exceeds global biocapacity, which is 1.8 gha per capita (GFN, 2009b). Food is a basic human need and its EF therefore cannot be diminished by a share equal to a factor such as the entire transport sector. Based on the availability of different land types (GFN, 2010), the current foodprint to EF ratio (Deumling et al. 2003), and the EF of a healthy diet (Frey & Barrett, 2007) an estimated 50% of total biocapacity must be reserved for food. Therefore, we propose the maximum allowed foodprint per world inhabitant is roughly 0.9 gha. This is the estimated available biocapacity for food produc-

tion if total global biocapacity were to be equitably allocated.

The Dutch Ministry of Economic Affairs, Agriculture, and Innovation has stated that “although the ‘foodprint’ of Dutch food is limited in absolute terms,” due to the country’s small size, “this is certainly not the case on a per capita basis” (LNV, 2009). The use of a global reference point emphasizes that if the world population were to adopt affluent Western lifestyles, we would be confronted with a shortage of land and energy, even more than is currently the case. With both the number of middle-class consumers and meat consumption expanding globally, this is a critical issue (Franz & Papyrakis, 2011). The disparity between the actual personal foodprint of about 2.1 and the available food biocapacity of 0.9 gha per capita is the main imperative for sensitizing consumers.

Most Consumers Are Not Aware of Their Foodprint

The foodprint is related to consumers’ personal food choices and behavior. Research shows little awareness among consumers of the environmental impact of what they eat, but many would likely be open to making more sustainable choices if it were easy to do so. Simpler, user-friendly information and advice about sustainable choices is therefore needed (Davies, 2011). A significant part of daily eating behavior is directed by habit, one of the most powerful predictors of eating behavior. Intentions, as opposed to habits, can be important determinants of nonhabitual eating behaviors. Habitual eating behaviors have a variety of determinants, one example being situational cues. Thus, an approach focusing on situational factors, self-regulation skills, and circumstantial factors may effectively target habitual eating behavior (Riet et al. 2011). A tool based on this idea could give consumers insight into these factors and make them aware of their dietary options and of possible ways to change their behavior. An integrated calculator can then demonstrate that their situation is unsustainable and offer insight and solutions for a sustainable food-consumption pattern.

The policy of the Dutch Ministry of Economic Affairs, Agriculture, and Innovation is aimed at reducing the per capita EF (LNV, 2009). According to the Ministry, “Particularly children and young people can learn to consciously think about what they eat and what effect it has on their health and ‘foodprint.’ The aim is to motivate them to opt for more sustainable and healthier food, now and in the future.” The foodprint concept is thus meant to raise awareness, and thereby contribute to a more environmentally friendly and healthier diet. While existing EF tools provide a measure of the extent of excessive con-

¹ The global hectare is normalized to the area-weighted average productivity of biologically productive land and water in a given year. Because different land types have different productivity, a global hectare of, for example, cropland, would occupy a smaller physical area than the much less biologically productive pasture land, as more pasture would be needed to provide the same biocapacity as one hectare of cropland (GFN, 2009a).

sumption and a benchmark for sustainability, they could be improved in a number of areas to provide practical interventions for education about sustainable behavior (Sutcliffe et al. 2008). Individual awareness about personal foodprints can be raised by developing a user-friendly foodprint tool (in Dutch “Voedselafdruk”) along with an effective communication strategy to reach consumers. These two processes are described in the next two sections.

Methodology: Development of a Food Choice-Based Tool

Scientific Indicators and Footprint Tools

Ecological, carbon, and water footprinting tools complement traditional analyses of human demand by coupling producer and consumer perspectives. These indicators present a quantifiable and rational basis for considering the efficiency of production processes, the limits of resource consumption, the international distribution of the world's natural resources, and the sustainability of ecological asset use around the world (Senbel et al. 2003; Galli et al. 2012). Various studies have shown that the EF can be used to evaluate different diets, food components, and production methods (Frey & Barrett, 2007). We chose the EF (Wackernagel & Rees, 1996; Wackernagel et al. 1999) as the most useful sustainability indicator for our prospective tool because:

- It expresses the different aspects of environmental impact in a single figure and thus provides an integrated indicator that allows comparisons among different products.
- It is simple and understandable and uses a unit that can easily be grasped, namely, a square meter of earth instead of carbon-dioxide (CO₂) emissions, nitrates, ozone, small particles, and so forth.
- It not only yields a footprint score, but this figure is also comparable to a clear and relevant limit—available land—as opposed to CO₂ emissions, which have no such strict boundary (GFN, 2009b).

We developed the footprint tool as a variation on the EF, basing it on Dutch data and creating it in compliance with the Ecological Footprint Standards 2009 (GFN, 2009a), designed to ensure that footprint assessments are produced in a consistent manner, according to community-proposed best practices, and that they are conducted and communicated in an accurate and transparent way. The Ecological Footprint Standards provide guidelines for factors such as the use of source data, derivation of conversion factors, establishment of study boundaries, and communication of findings. The standards apply to all footprint studies, including those targeting products. For a

more detailed discussion regarding the EF as an integrated indicator, see the section of this article entitled Shortcomings and Strengths of the EF Method.

Customized for Consumers

The footprint tool uses consumption-based accounting (CBA) (Galli et al. 2012). After years of debate, CBA is becoming increasingly accepted as it provides various handholds for policy and decision-making processes. CBA is a useful complement to territorially based approaches to ecological footprinting because it incorporates all the factors associated with the consumption activities driving demand on ecological assets. This method can be used to monitor the effects of decoupling consumption volume and ecological impact and to design strategic policies for sustainable consumption and production at the national, regional, and local levels (Galli et al. 2012). By integrating CBA, the EF tool may help the average individual understand her or his own EF and provide a useful indicator of global ecological overshoot, as per Sutcliffe et al. (2008).

Summarizing Personal Food Choices

Calculating an individual's footprint requires first compiling a concise summary of her or his personal food choices. The standard calculation method to determine an individual's EF is published in the Calculation Methodology for the National Footprint Accounts, 2010 edition (Ewing et al. 2010). The footprint tool was designed with a bottom-up CBA approach, based on data about the average consumption of a Dutch consumer. This approach is characterized by a sum of consumption activities, whereby each is the product of a consumption quantity (kilograms of food, kilowatt hours of energy, or kilometers of transportation as units of consumption) with a footprint intensity (gha per unit of consumption). These footprint intensities factor in yields on renewable products, life cycle analysis, data on the embodied energy of goods, direct CO₂ emissions from heating and mobility, and footprint data about agricultural land use (GFN, 2009a; Bellows et al. 2010; Ewing et al. 2010).

The footprint consists of four components: cropland—accounting for more than half the total footprint, grazing land (pasture), fishing grounds, and energy land (see Equation 1). These four components account for all the meat, fish, grain, and vegetables consumed directly by humans, as well as all of the meat, fish, grain, and energy used to feed, harvest, and ship food products. As stated, the EF is measured in a common unit called a global hectare, which is a unit of area with global average biomass productivity (see Footnote 1). Expressing EF in global hectares allows every footprint to be compared

with local or global biocapacity, including across regions that have different qualities and mixes of cropland, grazing land, and forest (Deumling et al. 2003). This also makes it possible to account for factors such as CO₂ sequestration by forests and oceans, to which end, in the case of forests, the Global Footprint Network (GFN) has determined a world average carbon sequestration factor (3.6 tons CO₂/gha). Other types of land are converted to global hectares by multiplying them by the corresponding equivalence factors, as calculated by Equation 1.

$$\begin{aligned} \text{EF food product} = & A \text{ cropland} * 2.51 + A \text{ pasture} \\ & * 0.46 + A \text{ fishing grounds} * 0.37 + (A \text{ built-up} \\ & \text{land}**) + \text{Em CO}_2 / 3.6 \end{aligned} \quad (1)$$

Where,

A = world hectares (wha)

EF = global hectares (gha) = A* equivalence factor (Eqf) [gha wha⁻¹]

Em = emissions CO₂ in tonnes (the factor is used to calculate the compensation area of forest)

** Built-up land should be included, but little data is available in practice (built-up land represents only 2% of a typical Dutch person's EF) (GFN, 2009a; Ewing et al. 2010).

System Boundaries: Measuring the Impact of Food Choices

The average foodprint of a Dutch consumer is 2.1 gha, which includes the EF of food (products), food waste, and energy use for cooking, packaging, and transport related to food consumption. Each factor is included in this foodprint calculator to make consumers aware that they have a significant influence on the household EF.

Consumers can use the foodprint tool to calculate their own foodprint by adapting an online description of a food pattern to their personal situation. This description is comprised of sentences with a colored (purple) section and linked to a multiple-choice pop-up screen (see Figure 1).

There are fifteen multiple-choice questions, based on a comprehensive selection of the system boundaries for the environmental impacts of food production and consumption. To make the foodprint tool as complete as possible, all the factors that have an impact on the EF and can broadly be attributed to food consumption are included: food and drink production and transport, food waste, energy use for cooking, mobility for grocery shopping, and packaging. The selected fifteen issues that contribute substantially to the foodprint are as follows: portion size; meat consumption; fish consumption; use of regional products; use of seasonal fruits and vegetables;



Figure 1 Online interface of the foodprint tool.

source of energy for cooking; cooking energy-use behavior; food waste; consumption of dairy; snacks; alcoholic drinks; coffee, tea, and water; juices and all other drinks; shopping behavior; and use of packaging.

The different answer options were designed to best reflect Dutch consumption behavior and described as clearly as possible so as to avoid overlap and ambiguity and to clarify the assumptions used to make the calculations; for example: "I eat meat on a regular basis: about 70 grams a day (500 grams a week)." At the same time, this design allowed an explicit description of the amounts used to calculate the environmental impact of meat consumption using the EF indicator.

These fifteen questions were then inserted into a formula for calculating the total foodprint (EF food), shown below in Equation 2.

$$\begin{aligned} \text{Total EF food} = & \sum (\text{EF meat} + \text{EF dairy} + \text{EF} \\ & \text{fish}) + (\text{EF drinks} + \text{EF alcohol} + \text{EF coffee \&} \\ & \text{tea}) + \% \text{ portion size} \times (\text{EF basic products} \\ & \text{region} + \text{EF fruits \& vegetables season} + \text{EF} \\ & \text{snacks} + \text{EF packaging}) + \text{EF shopping} \\ & \text{behavior} + (\% \text{ energy use} \times \text{EF energy source}) \\ & + \text{EF food waste} \end{aligned} \quad (2)$$

As shown in the formula above, the total foodprint (EF food) is calculated in six steps. The first

step measures the quantitative consumption of animal products that have the highest EF. The yearly consumption quantities (in kg/person/year) of the food products are multiplied by the corresponding footprint intensities (in global square meters/kg). The footprint intensities can be found in the National Footprint Accounts data tables (2010 edition) for the year 2007 (GFN, 2010). The calculation methodology used by GFN to assess the yield factors and the footprint intensities per product are described in the GFN methodology paper (Ewing et al. 2010).

According to these data, the following EFs have been determined: for meat 68 gm²/kg, for milk 18 gm²/liter, for cheese 180 gm²/kg, and for vegetables 7 gm²/kg. These footprint intensities include the use of agricultural land (cropland, grazing land, and fisheries area (when fish are used as feed)) as well as CO₂ emissions from production, excluding transport. The consumption quantities (in kg/year) are then multiplied with corresponding footprint intensities.

The second step is a semi-quantitative calculation of beverage consumption by frequency, which is translated to consumption quantity (liters/year) again and multiplied with corresponding footprint intensities.

Other food products are added up in the third step and multiplied by a factor for portion size (percentage). The consumption quantities in this third step are gauged by the consumption data for the Netherlands from the food-balance sheets produced by the United Nations Food and Agriculture Organization (FAO) (FAOSTAT, 2010). A portion size of 100% therefore corresponds with the consumption pattern of an average person in the Netherlands. Someone who eats more than an average person is assigned a higher percentage.

A separate question in the calculator is about the origin of the food products. The CO₂ emissions for transport (from producer to wholesale and retail) are translated in an energy-land footprint, based on transport data from Écolife (based on SWOV, 2010).

The above three steps comprise the food-products footprint, which includes the food wasted by Dutch households. Food-waste data are used to gauge the values in a separate question in the calculator on disposal (CREM, 2010).

Next to the footprint of the food products and food waste, the calculator also includes the energy-land footprint related to packaging and two consumer activities: consumer transport (shopping) and cooking at home. To calculate these factors, footprint-intensities data (energy-land per kg of packaging, per transport distance, and per kilowatt hour of cooking energy) from Écolife (based on GFN, 2010), together with household-survey data (from TNO, 1998; SWOV, 2010; CBS, 2011), are used to gauge the

values in the calculator. For cooking, two factors determine total energy use: the energy source and the efficiency. For someone on a raw food diet, for example, no energy use has to be accounted for. For someone who pays no attention to energy use while cooking (using no lids for example), by contrast, we multiply the average use per year per energy source with an efficiency factor of 120%.

This calculation method was developed in 2011 by Écolife; website designers at 3PO created the interface for the tool (see Figure 1).

Methodology Regarding Communication Strategy: Features of the Foodprint Tool

Communication through Social Media

Social networking is beginning to make an appearance on environmental websites. Awareness about environmental issues among social network members easily spreads throughout the entire network, and social media can be used to accelerate the diffusion of information and to expand possibilities to influence behavior. “Word-of-mouth marketing” and “viral marketing” (of which the “Voeroe” is an example; see the Section Customization of the Tool and Reaching the Consumer Context) seeks to join consumers in social networks and to use key people in these networks to launch a social epidemic (Tiemeijer et al. 2009). An approach that leverages popular social networking websites could have a powerful impact among individuals. Such platforms make possible frequent reminders and motivators, as well as, in this case, feedback about how well users score on their relative foodprint (Mankoff et al. 2007). Social networking websites are driven by bottom-up processes in which people organize themselves, share information and invest it with meaning (Tiemeijer et al. 2009). These are all factors that our communication strategy takes into account.

Easy to Use and Share

A crucial feature is that a foodprint tool should be easy to use and share through social networks. An important social environment factor is that people often consciously or unconsciously use simple decision rules to guide their choices. Cialdini (2001) calls this the “principle of social proof,” with an important consequence that ideas, norms, and behaviors can only spread through society if they are supported by social proof (Cialdini, 2001).² Following from this idea, the tool includes a feature that allows users to

² Social proof, also known as informational social influence, is a psychological phenomenon where people assume the actions of others in an attempt to reflect correct behavior for a given situation.

share their scores through social media (Twitter, Facebook, and the latter's Dutch equivalent, Hyves) after completing the questions. Additionally, users can see in real time how changing their food choices affects the environment. Thus, by modifying their input in the tool, users can see which choices would lead to a lower footprint. An additional screen provides advice on how to lower a user's footprint, based on the five areas in which she or he obtains the highest scores. Here the tool gives up to five customized suggestions on how to reduce the personal footprint, presented in random order. Users can use this advice to see how they might lower their score. Finally, they can share their personal footprint through social media such as Twitter and Facebook and ask their network, "How big is *your* footprint?"

Role of Consumer Context in Influencing Behavioral Intentions

Our communication strategy is based on the theory of contextual communication (Galimberti et al. 2001). In effect, our goal is to use peer groups and opinion leaders operating in their own online social "context" to influence personal intentions and choices and to set a social standard. The term "context" here is chosen because it ties in all the important elements related to an action (Galimberti et al. 2001). The core principle of contextual communication is that it starts with the consumer and her or his context, and not with the sender's message. Context also includes all elements in the environment that determine how a consumer perceives and interprets communication by public bodies (Tiemeijer et al. 2009).

The footprint tool can be used not only to raise awareness but also to influence behavioral intentions. Food choices mostly consist of habitual and planned behavior. According to the theory of planned behavior, first proposed by Ajzen & Madden (1986) and widely used in this domain, especially by social campaigns, several factors work together to determine behavioral intention. Crucially, this theory takes account of multiple points for influencing people's behavior: motivation (i.e., healthier diet), environmental influence (i.e., use of social networks), and perceived values (i.e., the average available footprint). This theory is therefore the basis of our contextual approach to communication.

Raising Awareness through Proactive Reflection and Feedback

Various footprint tools are already available on the Internet, including those of the Centre for Sustainable Economy and GFN (Franz & Papyrakis, 2011). While most of these EF calculations involve only a static questionnaire, incorporating dynamic

information about the positive and negative externalities of individual behavior on collective outcomes is important for defining the causal relationships between human activities and environmental outcomes. Reflexivity is essential, as transparency regarding the methods by which the EF is determined can further increase proactive reflective behavior among consumers (see the Section Feedback is Crucial and Helpful). If such aspects could be more readily incorporated, the EF calculator would be more constructive, furnishing a tool that includes local circumstances and connections between environmental goods and services and human use, and at the same time improving personal accountability (Saravanamuthu, 2009).

Our footprint tool is intended to provide that additional interactivity and reflectivity. For instance, if users change their preferences, the orange button indicating the score changes accordingly, thereby providing feedback on eating choices and habits. Mankoff et al. (2007) propose an approach that integrates feedback about EF data into existing social networking sites and Internet portals. Integrating such feedback into popular, commonly used sites would allow regular feedback about footprint performance, while also facilitating an exploration of the motivational schemes that drive group membership (Mankoff et al. 2007). The tool has therefore been designed to allow comparisons of personal scores with the "fair Earth share" of food, 0.9 gha, and the average Dutch footprint of 2.1 gha. A global reference is also provided, formulated along the following lines: "If everyone on the Earth had the same footprint as you, we would need 2.7 Earths." This type of reflection is an effective means of raising awareness (Franz & Papyrakis, 2011).

Intrinsic Motivation and Conditions for Effectiveness

Care for the Earth can be considered an external motivation for reducing one's footprint. Yet, over time, this motivation can also be internalized. This is because healthy food can only be generated by a healthy Earth and decreasing an individual's share and footprint affects her or his operating space and possibilities. An unequal share affects someone's feelings of guilt and competence, which are extrinsic motivators. Ryan & Deci (2000) point out that social contextual conditions that support our feelings of competence, autonomy, and relatedness form the basis for maintaining our intrinsic motivation (doing something because it is inherently interesting or enjoyable) and for growth in self-determination as regards extrinsic motivation (doing something because it leads to a separable outcome). We have drawn on this self-determination theory in designing

our foodprint tool, and specifically on Ryan & Deci's (2000) taxonomy of motivation, which sets out several stages moving successively from external to more internal motivation (Figure 2).

Results

The Tool Confirms the Problem: 95% Exceed Available Foodprint

The foodprint tool provides more than one billion possible outcomes, with a lowest possible score of 0.41 gha and a highest of 3.80 gha. The average score obtained using the tool was 1.83 gha (see Table 1). This amount comes close to the actual Dutch per capita average of 2.07 gha. The distribution in scores was close to normal, but slightly skewed toward a lower foodprint. This is probably to be expected, as tools of this kind often reach people who are most

aware of sustainability issues and eat more sustainably. Granting a normal distribution, the 2.5% lower limit is close to the available foodprint per world citizen (0.88 gha versus 0.9 gha). This means that more than 95% of Dutch consumers likely have a foodprint above the available gha. It is worth noting here that, in the majority of available indices included in existing tools, even selecting the most environmentally friendly options still results in footprints exceeding the planet's biocapacity levels (Franz & Papyrakis, 2011). In this tool, by contrast, it is also possible to score under this level.

The Tool Gives Practical Advice for a Healthy, Low Footprint Diet

The aim of the tool is not only to raise awareness about lowering the footprint through dietary behavior, but also to give practical advice about healthy eating. The tips provided in the tool's feedback component were formulated to address both aspects. The most important contributors to the average Dutch consumer's EF are animal products (50%), particularly dairy (22%), meat (17%), and fish (11%) (see Figure 3). Basic plant-based consumption, including local and seasonal production, contributes 24%. Packaging is also important, contributing 9%. Because shopping and cooking involve no direct land use, their share in the footprint is relatively small, only factoring in CO₂ releases (4%). If we look at the broader spectrum of household food-related GHG emissions, the total share is approximately 17% (Marinussen et al. 2010).

In 2011, the Dutch Health Council published *Guidelines for a Healthy Diet: The Ecological Perspective* (Health Council of the Netherlands, 2011) as

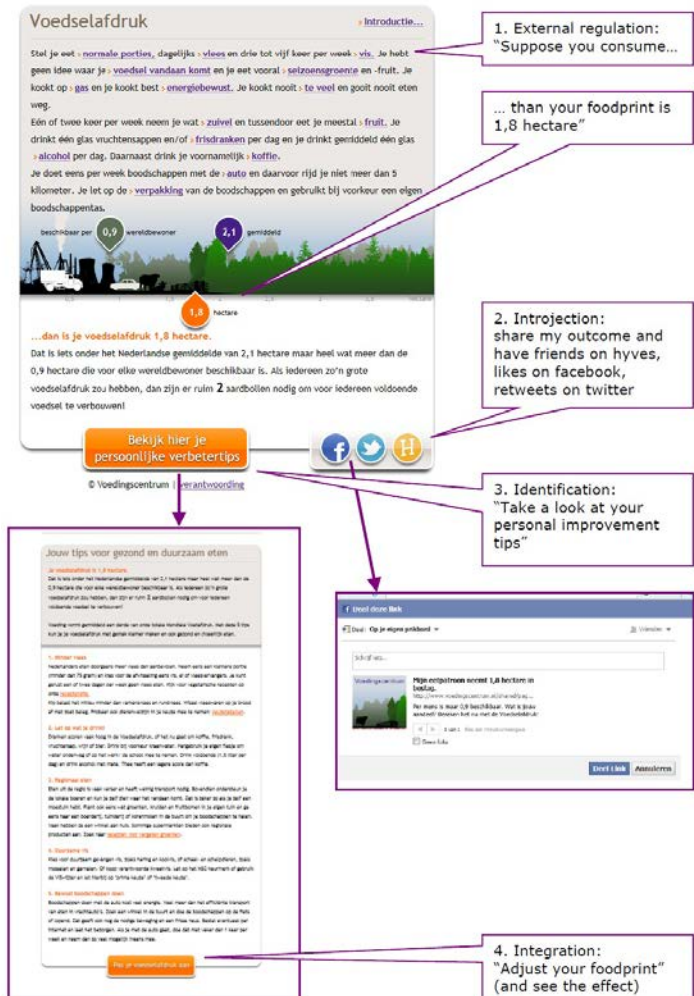


Figure 2 The taxonomy of motivation model (Ryan & Deci, 2000) as applied to the foodprint tool: four stages to a more intrinsic motivation.

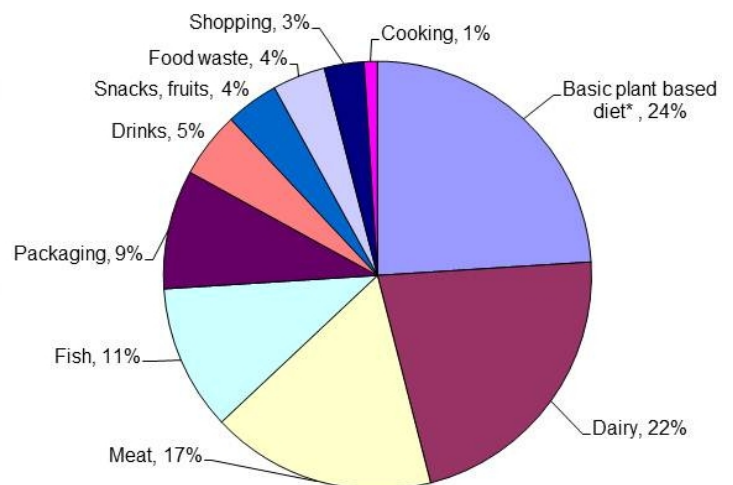


Figure 3 Composition of the average foodprint broken down by product group (vegetables, grains, bread, potatoes, vegetable oils).

Table 1 Three dietary patterns and their outcomes: modeled theoretical average score, ecologically friendly dietary guidelines, Dutch average.

Question	Average Score	Dutch Ecological Guidelines	Average Netherlands
1 Quantity	Normal portions	No more than necessary	Normal portions
2 Region	Don't know	All fruits & vegetables	Mostly the Netherlands or neighboring countries
3 Season	Frequently/depends	Almost all	Frequently/depends
4 Snacks, fruits	Sweet/snack 1–2X per day	Fruit 1–2X per day	Sweet/snack 1–2X day
5 Packaging	Responsible	Limited/recyclable	Responsible
6 Dairy	Daily some	1–2X per week	Daily some
7 Meat	Frequently (500g per week)	1–2X per week (200g)	Daily (1000g per week)
8 Fish	1–2X per week (200g)	1–2X per week (200g)	1–2X per week (200g)
9 Juices, soft drinks	1 glass per day	Sometimes, mostly water	1 glass per day
10 Alcohol	Frequently (1 unit per day)	2X per week	Frequently (1 unit per day)
11 Coffee/tea/water	Coffee & tea	Tea	Coffee
12 Shopping by	Car (1X per week)	Bicycle/feet	Car (1X per week)
13 Cooking	Responsible	Saving energy	Responsible
14 Energy source	Natural gas	Natural gas	Natural gas
15 Food waste	Sometimes	Almost never	Sometimes
Total score	1.83	0.96	2.07

a supplement to its existing Dutch Dietary Guidelines (Health Council, 2006). The accompanying report highlights two practical win-win guidelines that deliver both health and ecological benefits with respect to land use and GHG emissions:

1. Switch to a diet less reliant on animal products and more oriented toward plant-based products, with fewer dairy products and more whole grain products, legumes, vegetables, fruit, and plant-derived meat substitutes.
2. Reduce energy intake for those with an excessive body weight, in particular by eating fewer nonbasic foods such as sugary drinks, sweets, cakes, and snacks.

As meat and dairy account for 39% of the foodprint and nonbasic foods for 9%, most of the Health Council's guidelines are keyed to these products.

By contrast, the guideline for fish (11% of the foodprint) may yield health benefits but could also be ecologically detrimental, particularly to marine biodiversity:

3. Eat two fish portions per week, including at least one portion of oily fish (Health Council, 2011). Even though the indications are that a single portion of oily fish per week is enough to lower the risk of cardiovascular disease, this

recommendation of a single portion is still ecologically detrimental.

The foodprint tool was developed in conjunction with these science-based guidelines, which provided the parameters for the tool's questions, choices, and advice.

Customization of the Tool and Reaching the Consumer Context

We aimed to reach consumers in their own context through the Internet, social media, and games. Relying on what is known in the literature as “contextual communication” (see Methodology section), the tool approaches consumers in a manner keyed to their environment and personal setting and packages the message in an appealing manner, such as: “Suppose you consume...”

The tool was launched in August 2011 at the Lowlands cultural festival, where the famous Dutch comedian and environmental advocate Dolf Jansen was invited to be the first person to fill in the foodprint questionnaire (Figure 4). He subsequently tweeted his result of 1.2 gha to his 37,000 followers, generating media attention and a large number of visitors to the foodprint-tool website. In the final count, a total of 879 people shared their personal foodprints through Twitter, achieving a reach of 452,475 Twitter users.



Figure 4 Dutch comedian and environmental advocate Dolf Jansen (on the right).

In December 2011, we launched the “Voeroe” (a compound of the Dutch words for “food” and “guru”) as an innovative form of viral marketing. A fabricated Twitter personality, the “Voeroe” sent out 100 personal tweets with video messages to opinion leaders in the field of food and nutrition and to Dutch celebrities selected on the basis of their total number of Twitter followers. This resulted in a further 548 tweets and reached approximately 268,634 consumers.

In the last quarter of 2011, 90,000 consumers used the tool, a large number for an online environmental instrument. In total, news of the tool’s existence reached 721,000 consumers through social media (one in ten households in the Netherlands), of whom 12.5% actually used it. On average, the fifteen questions were answered in less than three minutes (the average webpage visiting time was two minutes, four seconds). Around 1% of users shared their outcome through Twitter or Facebook.

Discussion

Beyond the Dutch Health Council study (Health Council of the Netherlands, 2011), considerable additional international evidence points to the need for dietary changes aimed at healthier and more environmentally friendly consumption. Research conducted by Frey & Barrett (2007) shows that a diet that follows nutritional recommendations can significantly reduce the EF, with further reductions possible by choosing plant-based over animal-based foods and locally produced over imported food. Eshel & Martin (2009) identified red meat, and to a lesser extent the broader animal-based portion of the diet, as having the greatest environmental impact, with clear nutritional parallels. Carlsson & Gonzales’ (2009) suggestion that changing diet to include more plant-

based foods, meat from animals with little enteric fermentation, and foods processed in an energy-efficient manner offers an interesting prospect for mitigating climate change that has yet to be fully explored. Wolf et al. (2011) state that final consumption of food products is among the largest contributors to harmful environmental impacts in Europe, while the production of beef and pork at the agricultural level is responsible for the largest negative effects in the food-supply chain. A diet reflecting the healthy and ecologically friendly recommendations of the Health Council guidelines—with less meat and dairy,³ one portion of fish per week, no snacks between meals, and no food waste—would result in a foodprint of 0.96 gha (see Table 1). This figure is very close to the current available global capacity.

The recommendation of consuming less dairy can cause a dilemma. The Dutch nutritional recommendation for dairy consumption is 450–600 milliliters of milk and 30 grams of cheese per day (Voedingscentrum, 2011). This recommendation has a major influence on the foodprint. To keep within the limits of global capacity, dairy consumption actually needs to be reduced to once or twice a week, which conflicts with the health guidelines. This is one of the major sticking points for reaching a foodprint of 0.9 gha. One possible solution would be to shift the focus of dietary guidelines for calcium toward plant-based diets. The American Dietetic Association presents sound arguments for achieving this goal (Craig et al. 2009). A vegetarian diet that is varied and rich in wholegrain products, vegetables, pulses, and fruit, and that includes moderate amounts of dairy products and eggs, can meet the requirements of a healthy and wholesome diet. This diet can reduce the footprint by 40%, to a level less than 0.9 gha (Frey & Barrett, 2007).

The foodprint tool focuses on supporting more environmentally friendly dietary choices regarding the major food groups, but gives no advice about the environmental impacts of specific products. For example, the user can choose seasonal fruits and vegetables, but cannot see the exact impact of choosing lettuce from heated greenhouses or apples from New Zealand (Milà i Canals et al. 2007). This is a shortcoming of the tool, in that it cannot aid in product-level decision making at the point of sale. Rather, the

³ Other studies confirm the impact of animal products, which make up 50% of the average foodprint. Such products are also typically responsible for around 50% of GHG emissions; other basic food groups contribute 31% (Kramer et al. 1999). British studies have found GHG emissions for animal products ranging from 50% (Garnett, 2008) to 71% (Macdiarmid et al. 2011). Another British study attributed 61% of the EF of food to meat and dairy products; however, this work only included food production (not transport or cooking) (Collins & Fairchild, 2007).

tool gives useful recommendations for general dietary composition and specific behavioral tips, such as to drink tap water instead of coffee. Though we looked into possibilities for expanding the tool with different agricultural production methods, such as organic production, not enough conclusive data were available on the organic farming footprint (see e.g., Leifelt, 2012; Seufert et al. 2012).

A few scientists have criticized both the EF's concept and calculation method, leading to the conclusion that the EF is not as comprehensive and transparent a planning tool as has been assumed by Wackernagel, Rees, and others from the GFN (Van den Bergh & Verbruggen, 1999). In 2010, Van den Bergh & Grazi raised six main concerns about the EF. These relate to the calculation method, applications, and interpretations. The standard defense is that the EF is in its appearance simplified to a communication tool that converts unbelievers into believers in terms of recognizing the seriousness of environmental problems. However, a tool built on weak methodological foundations that offers false concreteness is compromised in providing a robust approach to creating consensus-based political support for environmental policies (Van den Bergh & Grazi, 2010). We have responded to the issue of false concreteness in the footprint tool by using an indicative scale with only one decimal place (for instance, 1.8 gha).

Fiala (2008) argued that the EF does not account for greenhouse-gas emissions other than CO₂, which may not be *ex ante* optimal, and arbitrarily assumes national boundaries as system boundaries, which makes extrapolating from the average ecological footprint problematic. According to Fiala, the footprint cannot take into account intensive production, and so comparisons to biocapacity are erroneous. While the creators of the EF agree that EF calculation methods can always be improved, they also state that Fiala (2008) has misunderstood several key points relating to the intended purpose and accepted appropriate use of EF calculations (Kitzes et al. 2009). In 2010, the method was adapted by GFN to incorporate new data, address the above criticism, and update the figures to make them more specific. The most significant change is in calculations relating to livestock and grassland (with respect to food), with the calculation of feed improved to reflect individual country practices rather than the universal average (including more species and more import/export data). The same applies to energy use per country (Ewing et al. 2010).

In a recent survey, experts concluded that it is time to be clearer about the EF and to recognize it as a powerful tool for communicating about human over-consumption, though at the same time remain-

ing aware of its limitations in other areas (Wiedmann & Barrett, 2010). In other words, it strongly points people in the correct direction to improve the environment, even if certain numbers might be imprecise. The EF can make a strong statement in reports identifying possible sources of unsustainability—in this case food—and communicating these to both the general public and political and corporate decision makers. Indeed, the EF makes a clear statement about over-consumption that has still not been accepted by governments or gained wide public awareness (Wiedmann & Barrett, 2010).

A study commissioned by the European Commission's Directorate General for the Environment identified the EF as effective for achieving targets and public communication, finding that, out of 25 methods, the footprint is the best available indicator. It can help to decouple economic growth from demand for raw materials; can provide insight into energy, climate, agriculture, and forest use; and can be applied to sustainable household consumption (Best et al. 2008). Additional key findings regarding the EF are:

- It is an intuitively appealing indicator (easy to understand, with a strong conservation message).
- Further improvements in data quality, methodologies, and assumptions are required. A lack of transparency regarding certain methodological aspects remains.
- A strong stakeholder network has emerged around the indicator, and opportunities exist for public sector involvement to further develop and refine the methodology (Best et al. 2008).

Franz & Papyrakis (2011) go a step further and formulate in theory specific conditions for an effective EF tool. In view of the need to communicate the imperative for sustainable behavior and the impacts of our individual actions, the tool could send a more powerful signal if it were designed to educate the user about the various impacts of different lifestyle choices, to unambiguously frame the problem, and to present options that prevent ecological deficits (i.e., external motivation). To accomplish this goal, the tool will necessarily need to incorporate more detailed local information, integrate a more dynamic analysis of key variables, and illustrate clearly the links among individual action and motivation and environmental impacts (Franz & Papyrakis, 2011). We are convinced that the footprint tool satisfies the conditions described by Franz & Papyrakis (2011).

Feedback is a critical component of lifestyle change because it can encourage reflection and support informed action. However, feedback is most helpful when combined with goal setting (intentional

implementation), as demonstrated in multiple studies of consumer-energy conservation (Mankoff et al. 2007), and now also borne out with the foodprint tool. Particularly useful in this regard is the information the tool provides after each question about why a certain option is “greener” than another. This directs consumers to make better choices to reduce their global footprint (Franz & Papyrakis, 2011).

Our application of self-determination theory in developing this tool is experimental, and may not hold as true in practice. After all, choices can also be determined by other factors, such as social pressure or intrinsic motivation. Studies concerning the impact and accuracy of health and other information disseminated via social networks are only beginning to be published, and our comprehension of the potential of social media is still in its infancy (Eytan et al. 2011). This article seeks to contribute to this understanding. Though the science of how networks can be used to accelerate behavior change is still in its incipient stages (Valente, 2012), the existing evidence indicates that network interventions are effective. Where the design of public campaigns is concerned, there are still few evidence-based guidelines on the use of online interventions.

In a review across all studies, Cugelman et al. (2011) found that the overall impact of online interventions is small but statistically significant, also providing the advantage of lower costs and greater reach. Time proves critical, with shorter interventions generally achieving larger impacts and greater adherence. In their psychological design, most of the effective interventions draw on the trans-theoretical approach and are goal oriented, deploying numerous influence components aimed at showing users the consequences of their behavior, assisting them in reaching goals, and exerting normative pressure. Inconclusive results suggest a relationship between the number of influence components (neither too many nor only a single one) and intervention efficacy (Cugelman et al. 2011). As demonstrated, the foodprint tool incorporates all three categories of influence components that we expect to result in a (small) significant impact on voluntary habitual behavior. Although actual behavior change has not been measured, we know that the tool reached 721,000 consumers through social media (one in ten households in the Netherlands) and 12.5% actually used it. Approximately 1% of the users shared their outcome through Twitter or Facebook, a step that can be interpreted as an intention to change food-choice behavior.

Given the large reach and low cost of online technologies, the stage may be set for a growing number of public health campaigns that blend interpersonal online methods with mass-media reach.

Such a combination of approaches could enable individuals to achieve personal goals to improve their individual well-being, while at a state level contributing to healthier and more sustainable societies (Cugelman et al. 2011), as we show in this study.

Conclusion

We have successfully developed the foodprint tool, which is different from existing EF tools in terms of 1) its focus on food only; 2) its innovative design that encourages interaction; and 3) its integration of recommendations for a healthy diet with a lower footprint. We succeeded in developing a food choices-based tool, with science-based indicators, that is custom-made for consumers by summarizing someone's personal food choices and measuring the impact of these choices. The well-chosen communication through social media strategy shows in practice that the foodprint tool is easy to use and share, available in the context of the consumer. The tool raises awareness by means of proactive reflection and feedback, using intrinsic motivation and conditions for effectiveness. Intervention through social media makes it possible to induce behavioral change with respect to food choices by showing users the consequences of their behavior, assisting them in reaching their goals, exerting normative pressure, and providing reference values and feedback.

The food tool results show that 95% of Dutch consumers are above the available footprint. It gives practical advice for a healthy and low-footprint diet and proves to be custom-made in the context of the consumer. The built in feedback is critical. The foodprint tool is powerful in that prompted food choices are both healthier and lower impact, although there seems to be a dilemma regarding the consumption of dairy. We have addressed the previously mentioned shortcomings of the ecological footprint methodology, although improvements are possible on the level of detail. This study confirms that the footprint is an appealing indicator for communication about the relationship between food consumption and its ecological impact on food production. Using social media appears effective and affordable for intervening in consumers' awareness and intentions.

In conclusion, the footprint provides a concise means of summarizing the environmental impact of individual food choices and can thereby help to raise awareness about over-consumption and set a social standard for environmentally friendly and healthy food choices.

Acknowledgment

Development of the foodprint tool and social media campaign was made possible by a grant from the Dutch Ministry of Economic Affairs, Agriculture, and Innovation.

References

- Craig, W., Mangels, A., & American Dietetic Association (ADA). 2009. Position of the American Dietetic Association: vegetarian diets. *Journal of the American Dietetic Association* 109(7):1266–1282.
- Ajzen, I. & Madden, T. 1986. Prediction of goal-directed behavior: attitudes, intentions, and perceived behavioral control. *Journal of Experimental Social Psychology* 22(5):453–474.
- Bellows, A., Alcaraz V., & Hallman, W. 2010. Gender and food, a study of attitudes in the USA towards organic, local, U.S. grown, and GM-free foods. *Appetite* 55(3):540–550.
- Best, A., Giljum, S., Simmons, C., Blobel, D., Lewis, K., Hammer, M., Cavalieri, S., Lutter, S., & Maguire, C., 2008. *Potential of the Ecological Footprint for Monitoring Environmental Impacts from Natural Resource Use: Analysis of the Potential of the Ecological Footprint and Related Assessment Tools for Use in the EU's Thematic Strategy on the Sustainable Use of Natural Resources*. Brussels: DG Environment.
- Billen, G., Garnier, J., & Barles, S. 2012. History of the urban environmental imprint: introduction to a multidisciplinary approach to the long-term relationships between Western cities and their hinterland. *Regional Environmental Change* 12(2):249–253.
- Central Bureau of Statistics (CBS). 2011. Population: Key Figures. <http://statline.cbs.nl/StatWeb/publication/?DM=SLLEN&PA=37296eng&D1=0-2,8-24,52-56&D2=0,10,20,30,40,50,61-63&LA=EN&HDR=G1&STB=T&VW=T>. March 28, 2012.
- Carlsson-Kanyama, A. & Gonzalez, A. 2009. Potential contributions of food consumption patterns to climate change. *American Journal of Clinical Nutrition* 89(5):1704S–1709S.
- Cialdini, R. 2001. *Influence: Science and Practice*. Boston: Allyn & Bacon.
- Collins, A. & Fairchild, R. 2007. Sustainable food consumption at a sub-national level: an ecological footprint, nutritional and economic analysis. *Journal of Environmental Policy & Planning* 9(1):5–30.
- Consultancy and Research for Environmental Management (CREM). 2010. *Bepaling Voedselverliezen bij Huishoudens en Bedrijfscatering in Nederland [Determination of Food Waste from Households and Business Catering in the Netherlands]*. Amsterdam: CREM (in Dutch).
- Cugelman, B., Thelwall, M., & Dawes, P., 2011. Online interventions for social marketing health behavior change campaigns: a meta-analysis of psychological architectures and adherence factors. *Journal of Medical Internet Research* 13(1):e17.
- Davies, S. 2011. Making sustainable choices easier. *Nutrition Bulletin* 36(4):454–459.
- Deumling, D., Wackernagel, M., & Monfreda, C. 2003. Eating up the earth: how sustainable food systems shrink our ecological footprint. *Agriculture Footprint Brief* July:1–12.
- Dutilh, C. & Kramer, K. 2000. Energy consumption in the food chain. *Ambio* 29(2):98–101.
- Eshel, G. & Martin, P. 2009. Geophysics and nutritional science: toward a novel, unified paradigm. *American Journal of Clinical Nutrition* 89(5):1710S–1716S.
- Ewing, B., Reed, A., Galli, A., Kitzes, J., & Wackernagel, M. 2010. *Calculation Methodology for the National Footprint Accounts*. Oakland, CA: Global Footprint Network.
- Eytan, T., Benabio, J., Golla, V., Parikh, R., & Stein, S., 2011. Social media and the health system. *The Permanente Journal* 15(1):71–73.
- FAOSTAT. 2010. Food Balance Sheets. Rome, Italy. <http://faostat.fao.org/site/354/default.aspx>. March 28, 2012.
- Fiala, N. 2008. Measuring sustainability: why the ecological footprint is bad economics and bad environmental science. *Ecological Economics* 67(4):519–525.
- Franz, J. & Papyrakis, E. 2011. Online calculators of ecological footprint: do they promote or dissuade sustainable behaviour? *Sustainable Development* 19(6):391–401.
- Frey, S. & Barrett, J. 2007. *Our Health, Our Environment: The Ecological Footprint of What We Eat*. International Ecological Footprint Conference. May 8–10, Stockholm Environment Institute, Cardiff.
- Galimberti, C., Ignazi, S., Vercesi, P., & Riva, G. 2001. Communication and cooperation in networked environments: an experimental analysis. *Cyberpsychology and Behavior* 4(1):131–146.
- Galli, A., Wiedmann, T., Ercin, E., Knoblauch, D., Ewing, B., & Giljum, S. 2012. Integrating ecological, carbon and water footprint into a “footprint family” of indicators: definition and role in tracking human pressure on the planet. *Ecological Indicators* 16:100–112.
- Garnett, T. 2008. *Cooking Up a Storm: Food, Greenhouse Gas Emissions and Our Changing Climate*. Surrey: Food Climate Research Network.
- Garnett, T. 2011. Where are the best opportunities for reducing greenhouse gas emissions in the food system (including the food chain)? *Food Policy* 36(1):S23–S32.
- Global Footprint Network (GFN). 2009a. *Ecological Footprint Standards 2009*. Oakland, CA: GFN.
- Global Footprint Network (GFN). 2009b. *How We Can Bend The Curve*. Oakland, CA: GFN.
- Global Footprint Network (GFN). 2010. *National Footprint Accounts Data Tables, NFA*. Oakland, CA: GFN.
- Health Council of the Netherlands, 2006. *Richtlijnen Goede Voeding [Guidelines for a Healthy Diet]*. The Hague: Health Council of the Netherlands (in Dutch).
- Health Council of the Netherlands. 2011. *Guidelines for a Healthy Diet: The Ecological Perspective*. The Hague: Health Council of the Netherlands.
- Hedden, W. 1929. *How Great Cities are Fed*. New York: D.C. Heath & Co.
- Hoekstra, A. & Chapagain, A. 2004. *Water Footprints of Nations*. Value of Water Research Report Series No. 16. Delft: UNESCO-IHE.
- Kitzes, J., Moran, D., Galli, A., Wada, Y., & Wackernagel, M. 2009. Interpretation and application of the ecological footprint: a reply to Fiala (2008). *Ecological Economics* 68(4):929–930.
- Kramer, K., Moll, H., Nonhebel, S., & Wilting, H. 1999. Greenhouse gas emissions related to Dutch food consumption. *Energy Policy* 27(4):203–216.
- Leach, A., Galloway, J., Bleeker, A., Erisman, J., Kohn, R., & Kitzes, J. 2012. A nitrogen footprint model to help consumers understand their role in nitrogen losses to the environment. *Environmental Development* 1(1):40–66.
- Leifeld, J. 2012. How sustainable is organic farming? *Agriculture, Ecosystems & Environment* 150:121–122.
- Ministerie van Landbouw, Natuurbeheer en Voedselkwaliteit (LNV). 2009. Nota duurzaam voedsel [Sustainable food paper]. The Hague: LNV (in Dutch).
- Macdiarmid, J., Kyle, J., Horgan, G., Loe, J., Fyfe, C., Johnstone, A., & McNeill, G. 2011. *Livewell: A Balance of Healthy and Sustainable Food Choices*. Surrey: WWF-UK.
- Mankoff, J., Matthews, D., Fussell, S., & Johnson, M. 2007. *Levelling Social Networks to Motivate Individuals to Reduce their Ecological Footprints*. 40th Hawaii International Conference on Systems Science. January 3–6, Waikoloa; IEEE Computer Society.
- Marinussen, M., Blonk, H., & van Dooren, C., 2010. *Naar een Gezond en Duurzaam Voedselpatroon, een Verkenning Naar Potenties en Dilemma's [Towards a Healthy and Sustainable Diet: An Exploration of Potentials and Dilemmas]*. Gouda,

- Netherlands: Blonk Milieu Advies/Voedingscentrum (in Dutch).
- Milà i Canals, L., Cowell, S., Sim, S., & Basson, L. 2007. Comparing domestic versus imported apples: a focus on energy use. *Environmental Science and Pollution Research* 14(5): 338–344.
- Peters, C., Bills, N., Lembo, A., Wilkins, J., & Fick, G. 2009a. Mapping potential foodsheds in New York State: a spatial model for evaluating the capacity to localize food production. *Renewable Agriculture and Food Systems* 24(1):72–84.
- Peters, C., Bills, N., Wilkins, J., & Fick, G. 2009b. Foodshed analysis and its relevance to sustainability. *Renewable Agriculture and Food Systems* 24(1):1–7.
- Riet, J.v.t., Sijtsema, S., Dagevos, H., & De Bruijn, G.-J. 2011. The importance of habits in eating behavior: an overview and recommendations for future research. *Appetite* 57(3):585–596.
- Rockström, J., Steffen, W., Noone, K., Persson, A., Chapin, F., Lambin, E., Lenton, T., Scheffer, M., Folke, C., Schellnhuber, H., Nykvist, B., de Wit, C., Hughes, T., van der Leeuw, S., Rodhe, H., Sorlin, S., Snyder, P., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R., Fabry, V., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P., & Foley, J. 2009. A safe operating space for humanity. *Nature* 461(7263):472–475.
- Ryan, R. & Deci, E. 2000. Intrinsic and extrinsic motivations: classic definitions and new directions. *Contemporary Educational Psychology* 25(1):54–67.
- Saravanamuthu, K. 2009. A journey of socialising the risks associated with global warming: a Gandhian insight into Schumacher's total accounting and accountability. *Advances in Public Interest Accounting* 14:121–189.
- Seligman, C. & Darley, J. 1977. Feedback as a means of decreasing residential energy consumption. *Journal of Applied Psychology* 62(4):363–368.
- Senbel, M., McDaniels, T., & Dowlatabadi, H. 2003. The ecological footprint: a non-monetary metric of human consumption applied to North America. *Global Environmental Change* 13(2):83–100.
- Seufert, V., Ramankutty, N., & Foley, J. 2012. Comparing the yields of organic and conventional agriculture. *Nature* 485(7397):229–232.
- Stehfest, E., Bouwman, L., van Vuuren, D., den Elzen, M., Eickhout, B., & Kabat, P. 2009. Climate benefits of changing diet. *Climatic Change* 95(1):83–102.
- Stichting Wetenschappelijk Onderzoek Verkeersveiligheid (SWOV). 2010. *SWOV Fact Sheet: Mobility on Dutch Roads*. The Hague: SWOV.
- Sutcliffe, M., Hooper, P., & Howell, R. 2008. Can eco-footprinting analysis be used successfully to encourage more sustainable behaviour at the household level? *Sustainable Development* 16(1):1–16.
- Tiemeijer, W., Thomas, C., & Prast, H. 2009. *De Menselijke Beslissers: Over de Psychologie van Keuze en Gedrag [The Human Decision Maker: The Psychology of Choice and Behavior]*. Amsterdam: Amsterdam University Press (in Dutch).
- Nederlandse Organisatie voor Toegepast-Natuurwetenschappelijk Onderzoek (TNO). 1998. *Voedsel Consumptie Peiling 1997–1998 [Food Consumption Survey 1997–1998]*. The Hague: TNO/Voedingscentrum (in Dutch).
- Tukker, A., Huppes, G., Guinée, J., Heijungs, R., de Koning, A., van Oers, L., Suh, S., Geerken, T., Van Holderbeke, M., Jansen, B., & Nielsen, P. 2006. *Environmental Impact of Products (EIPRO): Analysis of the Life Cycle Environmental Impacts Related to the Final Consumption of the EU-25*. IPTS/ESTO Project. Seville: European Commission.
- Valente, T. 2012. Network interventions. *Science* 337(6090):49–53.
- Van den Bergh, J. & Grazi, F. 2010. On the policy relevance of ecological footprints. *Environmental Science & Technology* 44(13):4843–4844.
- Van den Bergh, J. & Verbruggen, H. 1999. Spatial sustainability, trade and indicators: an evaluation of the “ecological footprint.” *Ecological Economics* 29(1):61–72.
- Voedingscentrum. 2011. *Richtlijnen Voedselkeuze [Guidelines for Food Choices]*. The Hague: Voedingscentrum (in Dutch).
- Vringer, K., Benders, R., Wiling, H., Brink, C., Drissen, E., Nijdam, D., & Hoogervorst, N. 2010. A hybrid multi-region method (HMR) for assessing the environmental impact of private consumption. *Ecological Economics* 69(12):2510–2516.
- Wackernagel, M., Onisto, L., Bello, P., Linares, A., Falfan, I., García, J., Guerrero, A., & Guerrero, M. 1999. National natural capital accounting with the ecological footprint concept. *Ecological Economics* 29(3):375–390.
- Wackernagel, M. & Rees, W. 1996. *Our Ecological Footprint, Reducing Human Impact on the Earth*. Gabriola Island, BC: New Society Publishers.
- Wiedmann, T. & Barrett, J. 2010. A review of the ecological footprint indicator: perceptions and methods. *Sustainability* 2(6): 1645–1693.
- Wiedmann, T. & Minx, J. 2008. *A Definition of “Carbon Footprint.”* Hauppauge, NY: Nova Science Publishers.
- Wolf, O., Pérez-Domínguez, I., Rueda-Cantuche, J., Tukker, A., Kleijn, R., de Koning, A., Bausch-Goldbohm, S., & Verheijden, M. 2011. Do healthy diets in Europe matter to the environment? A quantitative analysis. *Journal of Policy Modeling* 33(1):8–28.