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The Nutritional Footprint – integrated methodology using environmental and health indicators to indicate potential for absolute reduction of natural resource use in the field of food and nutrition

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Keywords: nutritional footprint, health indicators, environmental indicators, sustainable food, resource productivity

Abstract

The field of nutrition will face numerous challenges in coming decades; these arise from changing lifestyles and global consumption patterns accompanied by a high use of resources. Against this background, this paper presents a newly designed tool to decrease the effect on nutrition, the so-called Nutritional Footprint. The tool is based on implementing the concept of a sustainable diet in decision-making processes, and supporting a resource-light society. The concept integrates four indicators in each of the two nutrition-related fields of health and environment, and condenses them into an easily communicable result, which limits its results to one effect level. Applied to eight lunch meals, the methodology and its calculations procedures are presented in detail. The results underline the general scientific view of food products; animal-protein based meals are more relevant considering their health and environmental effects. The concept seems useful for consumers to evaluate their own choices, and companies to expand their internal data, their benchmarking processes, or their external communication performance. Methodological shortcomings and the interpretation of results are discussed, and the conclusion shows the tools' potential for shaping transition processes, and for the reduction of natural resource use by supporting food suppliers' and consumers' decisions and choice.

1 Introduction

Today, total resource use is about 4 to 5 times higher than the suggested sustainable level, and scientists agree that changes have to be undertaken in all fields as soon as possible (Bringezu, 2011). The relation between the volume of natural resources used by the human economy and the degree of environmental effect has already been stated in the late 1960s (Ayres & Kneese, 1969). Today, the discussion on the topic of transition to sustainability (Schneidewind & Scheck, 2012) is often focussed on the fields of mobility, housing, nutrition and even leisure-time activity (Buhl, 2014; Kotakorpi et al., 2008; Leismann et al., 2013; Røpke, 2009) owing to their high share of the overall resource consumption. A fundamental change in the fields is required, which may lead to a transformation of our economic system, culture and lifestyle (Fuchs & Lorek, 2005; Geels, 2011; Rohn et al., 2013). The Sustainable Development Goals (UNEP 2014) focus on health and environmental indicators relating to specific targets and indicators for food, water, agriculture, but also on management systems, which encourage current behaviour and business implementation, which are insufficiently integrated and remain very abstract in every field of action. Consequently, a sustainable Material Footprint framework of '8 tons per person and year' owing to the different fields of consumption and depending on the situation and requirements of each household seems reliable within this examination (Lettenmeier et al., 2014). This paper will, therefore, focus on the food and nutrition sector which accounts for 29 % of the global emission of greenhouse gases (GHG), and for a high use of water and land, and so a high resource use (Carlsson-Kanyama & Gonza, 2009; Giljum et al., 2009; Hoekstra & Mekonnen, 2012; Vermeulen et al., 2012). Additionally, it should be underlined that if nutrition is to develop towards sustainability, environmental and health aspects should be considered in relation to each other (Wirsam & Leitzmann, 2011). However, currently available conceptual drafts only consider one field of investigation and are limited to their field of scientific expertise. Reflecting this precondition, this paper will present the newly established approach, which integrates health and environmental indicators. In the first sections, this paper provides an overview of health and environmental aspects in relation to sustainable nutrition. In section 3, a closer look is taken at the materials and methods used to compose the Nutritional Footprint. Section 4 then gives details on the calculation of the Nutritional Footprint of eight German lunch meals, and the reduction potential resulting from the results of the indicators. Finally, the final conclusions and outlook are presented in section 5.

2 Background and theoretical framework

2.1 Objective - Sustainability of Nutrition

When allocating sustainable levels of natural resource consumption to different consumption fields, such as mobility, housing, and leisure-time activity, the field of nutrition which probably includes the most basic needs humans have, plays a special role; it might not be reduced to the same degree as other fields of action. For instance, Kotakorpi et al. (2008) show a smaller elasticity in the area of nutrition with a factor of 3, in comparison to a factor of 85 for mobility. Interestingly, the indication from the scientific evaluation of nutrition and public health science and environmental science generally point in the same direction; the reduction of consumption rates of meat products or the reduction of food waste are deemed important for the future in both fields (e.g. Bernstad & Jansen, 2011; FAO, 2013; Gustavsson et al., 2011).

However, the determination of absolute levels or benchmarks for sustainable production and consumption is complex and not unambiguous (e.g. Bringezu et al., 2009; Lettenmeier et al., 2012a, 2012b; Nissinen et al., 2007; Rohn et al., 2014), especially when attempting to implement general sustainability targets to a level of specific consumption components such as several meals or dishes(Macdiarmid et al., 2011; Risku-Norja et al., 2010). Thus, a footprint tool, which condenses the results of health-related and environment-related indicators into an easily communicable result and limits its results to one effect level is desirable.

This is one of the central issues of this paper, as the evaluation on the level of diets and meals is essential for making sustainable nutrition feasible. Arising from these indicators, the main objective in this paper is an initial methodical exploration of the dimensions of 'health' and 'environment', and a first methodological combination of both by using adequate indicators in one footprint tool.

2.2 Health indicators to be considered in the field of nutrition

The health characteristics of nutrition have been the main object of discussion for a long time, and various indicators have been used to describe them. For this study, we have analysed several indicators suitable for the assessment of health characteristics of a regular diet, the '*daily energy intake*', the indications of '*dietary fibre*', *'folate'* or *'iron'* or even the '*sodium intake*' and the indicator of '*saturated fat*'.

The basis of indicators and nutrition recommendations for several age groups is globally and nationally robust and is updated regularly; this is due to the long research history of nutrition science with intervention and in vitro studies although such knowledge is not exhausted. The choice presented has been made with the view of integrating the most common indicators (food energy) and the ones which are analysed have being relevant in the current debate in nutrition science (dietary fiber or vitamin B12). The indicators analysed are very different in their alignment and in their expressiveness. The indicator ‘energy’, one of the most often measured intake factors in nutrition surveys, displays the overall energy contained without any further differentiation. Other indicators such as ‘saturated fat’ display a negative effect while indicators such as ‘dietary fibre’ denote a positive effect on health of a food product.

The need for energy from food intake is individual and affected by different factors - physical activity (Leitzmann et al., 2009). The majority of consumers are familiar with kilocalories (kcal), and the indicator ‘energy’ can generally be seen as one of the most important indicators (Max Rubner-Institute, 2008a, 2008b). Nowadays, the availability of food products, which means food ‘energy’ is higher than it has ever been before, and obesity causes five percent of all deaths (Hill et al., 2012). The indicator of ‘saturated fat’ is relevant because a high intake of saturated fatty acids is responsible for a high cholesterol level, which can increase the risk of cardiovascular disease. These acids are mainly found in animal products such as meat, butter and cream (Mozaffarian et al., 2010; Skeaff & Miller, 2009). ‘Sodium’ is a relevant indicator as high salt input is a common problem worldwide, and the intake level in industrialised countries is significantly higher than the recommendations of WHO or national agencies. The content of ‘dietary fibre’ is a positive indicator in evaluating food products. The presence of dietary fibre increases the food volume without increasing the energy content, while binding relatively large amounts of water; this leads to directly increased satiety. Folate, iron and vitamin B12 are currently in the focus of nutrition science (Elzen et al., 2010; Koletzko et al., 2013;Waldmann et al., 2004).

2.3 Environmental indicators to be considered in the field of nutrition

The environmental characteristics of nutrition have not been a central object of scientific debate although they were considered more intensively for some years. In the discussion on agricultural and food systems and nutrition, several environment-related indicators are useful. After intensive exploration, four macro indicators with a high relevance for the environmental effect of food production and consumption have been identified from literature sources and in terms of applicability: *'Carbon Footprint', 'Material Footprint', 'Land use'* and *'Water* ***F****ootprint'*. These indicators have several underlying types of methodology that may be applied; therefore, it was important to analyse these different types of methodology to reveal their respective relevance for the Nutritional Footprint.

The 'Carbon Footprint' is the overall amount of GHG associated with a product life cycle. From the different standards defining the Carbon Footprint, the ISO 14067 was chosen as the most recent guideline and the one, which allows consistent results (Goedkoop et al., 2009). The Carbon Footprint has become increasingly popular and is well accepted in scienctific and industrial fields (Schmidt, 2008), but as an output indicator related to just one environmental effect it has to be supplemented by using a comprehensive input indicator to analyse abiotic and biotic material flows in broader terms. With regard to this issue, the 'Material Footprint', which is based on the 'MIPS concept' (Material Input Per Unit of Service), was considered as a complementary indicator. Thus, a combination allows an approximate assessment of the overall environmental burden (Lettenmeier et al., 2009) and as Liedtke et al. (2014) state: "… the input-oriented MIPS concept is mostly compatible to an output-oriented LCA." The idea of the 'MIPS concept' is the analysis of all potential environmental effects resulting from natural resource use as a whole (Liedtke et al., 2014; Lettenmeier et al., 2009; Ritthoff et al., 2002; Schmidt-Bleek, 2009). For its application in the Nutritional Footprint, the Material Footprint considers two resource categories: the category 'Abiotic Raw Materials' includes mineral raw materials, fossil fuels and spoils (overburden from mining or excavated materials when building an infrastructure) and the category 'Biotic Raw Materials' considers plant biomass from cultivation. All in all, both indicators fit very well in use, but the effects of land use or water consumption are still not included in both indicators. Both categories are important in an assessment of agricultural production systems, which are very relevant for food products.

There are different approaches available to measure the use of land. Some approaches distinguish between different land categories (agricultural, urban, natural land) and offer stock models, or assess the ecosystem service of land (Bare, 2010; Heijungs et al., 1997; Mila i Canals & Romanya, 2007). For the nutrition-focused approach, a simple model may be useful: It covers all land occupied. All land types are equivalent and land use effects do not depend on land characteristics (Hischier & Weidema, 2009). Hence, there is good data availability, which approximately covers the 9.000 processes included in ECOINVENT 3 (Moreno Ruiz et al., 2013).

There are as well several types of methodology to calculate the 'Water Footprint' as an indicator for the total volume of water used throughout the life cycle of a product (Berger & Finkbeiner, 2010). The concept 'virtual water' defined by the Water Footprint Network considers three categories whereas the MIPS concept considers the water input as the amount of water actively taken from nature or retained. All types of methodology have been questioned with reference to data availability in literature and databases (Wiesen et al., 2014). The Water Footprint of the Nutritional Footprint should be calculated as was proposed in Wiesen et al. (2014) in the future, but owing to current data available, the 'Water footprint' is applied (Mekonnen & Hoekstra, 2011, 2012). All in all, these four indicators were chosen to cover this very complex field to assess the environmental effects of food production and consumption.

3 Material and method

3.1 Selection of indicators

In order to assess frequently used indicators, current scientific contributions with relevance in terms of both health and environmental indicators were analysed. The goal was to select a manageable number of indicators that are measurable, applicable and easy to understand (see 2.2). First considerations concerning the Nutritional Footprint have been proposed by Lukas et al. (2013a, 2013b). During the earlier development phase of the concept (Lukas et al. 2013b), a few more indicators were selected, but after a qualitative scientific revision which reconsidered current research activity and the significance of the indicators, the amount of indicators was decreased. Now, the Nutritional Footprint condenses the results of four health-related and four environment-related indicators into an easily communicable result and limits its results to one effect level. The amount of four indicators was chosen to display several different indications and to condense a high-range of information in the field of nutrition. Therefore, the selection of indicators was highly orientated towards current scientific discussion on the most reliable and also wide-ranged indicators (Table 1). Further, to confirm a consistent calculation and to compare with the macro level, we propose a ‘cut off’ (0:100 allocation).

Table 1: Indicators included in the Nutritional Footprint (source: own)

Health indicators	**Environmental indicators**
Energy intake (kcal)	*Material Footprint (g)*
Sodium intake (g)	*Carbon Footprint (g CO_2eq)*
Content of dietary fibre (g)	*Water Footprint (l)*
Saturated fat (g)	*Land use (m^2)*

3.2 Determining threshold levels

During the development of the footprint approach, the question arose which classification can be set in the context of the rankings presented. As a result of this classification idea, the threshold levels were invented and applied on a three-level scale. It was stipulated that the lower level should also have a different function: the determination of a sustainable diet (Clonan & Holdsworth, 2012; Sabaté & Soret, 2014). Thus, national and international recommendations were analysed to create adequate assessment and ranking levels which indicate a sustainable diet. The approved recommendation data in the health sector are useful and valid. International public health standards, European recommendations on diets and nutrition, and national recommendation guidelines provide a valid basis (DGE, 2012, 2013; FDF, 2013; Lichtenstein et al., 2006; WHO, 2000). In order to facilitate the handling of the data of health indicators, the GDA recommendation and benchmark level by 2000 kcal per day as guideline were chosen (FDF, 2013). As displayed in Formula 1, this level considers all meals and all drinks per day:

Formula

$$GDA_{2000\,kcal} = \sum meals_{n1+n2+n3+n(...)} + \sum drinks_{n1+n2+n3+n(...)} \qquad (1)$$

Owing to valid databases, the calculation of health values can be based on general nutrition guidelines (see: DGE 2011 or FDF 2013) which are also useful to indicate a sustainable diet. The national and international recommendations on nutrition were used as ‘small effect’ threshold values because if everybody considers these recommendations, animal-related products will very simply be reduced. The levels of the strong effect values are based on the

presumption that current intake levels are often higher than recommendation levels are, and so present average values are set as threshold for high effect (see: Max Rubner-Institute, 2008a). The more important challenge was the examination of the environment-related levels. From the environmental perspective, a highly but not totally vegetarian nutrition, a slightly lower intake of foodstuffs (600 kg / (person*a)) compared to today, and efficiency gains in the food chain by reducing waste (Lettenmeier et al., 2014, Lettenmeier et al., 2012a; Macdiarmid et al., 2012), may be valid. Thus, for a vegan diet, the Material Footprint can be 6 kg/day, while the Material Footprint for a day of a meat-based diet will hardly be below 15 kg/day (Wuppertal Institute, 2014; Kotakorpi et al., 2008; Lettenmeier et al., 2012c). Considering this, a reduction factor 2-3 of present resource use, based on levels in Lettenmeier et al. (2014; 2012c) is desirable. Finally, the environmental research perspective already provides a wide range of starting points and future recommendations which are summarised in Appendix 1. Thus, the threshold levels were examined with the idea of setting the strong input thresholds levels at 75 % of the present or recent values of nutrition in households. The low input thresholds were set at the values proposed sustainable according to the reference in question.
Table 2 displays the most essential recommendations and the proposal for a recommendation of threshold levels in the environmental-related perspective. For instance, the Material Footprint of Lettenmeier et al. (2014) refer to 8 tons (cap/a) as an overall resource cap target for households. In terms of nutrition, a reduction from 5.9 tons of 3 tons is necessary for this. The recent resource consumption rate for nutrition is 16 kg/d/cap, what means recently 16kg of resources are consumed per day and person. With a minus of 25 %, the threshold for the strong effect level is set at 12 kg/d/cap. The threshold level for a small effect was set at the level proposed as a sustainable Material Footprint for nutrition.

Table 2: Basic estimations for threshold levels of environmental indicators (source: own)

Indicator	*Current consumption level (estimation)*	*Recommendation*	*Source*		*Proposal for the Nutritional Footprint level: Strong impact (-25%)*	*Proposal for the Nutritional Footprint level: Low impact (-50%)*
Material Footprint	5.9 tons (16kg/d/cap) (Finland)	Minus of 50%	Lettenmeier et al. 2014		12kg/d/cap	8 kg/d/cap

Carbon Footprint	4.8 kg CO_2 eq/d/cap (Germany) 6.78kg CO_2 eq/d/cap (UK) 4.4 kg/d/cap(Finland)	Minus of 30-50%	UBA (2007) Macdiarmid et al. 2012 Seppälä et al. 2011		3.6 kg CO_2 eq /d/cap	2.4 kg CO_2 eq /d/cap
Water footprint	3900 l/d/cap(Germany)	Minus of 35%	Mekonnen & Hoekstra 2012		2925 l/d/cap	1950 l/d/cap
Land use	Typical meals: 0,46-3,61m^2 High rates of meat-based diets may have to be considered with 5-10m^2/cap/d (nutrition) 20 m2/d/cap (7300m2/y/cap) (Overall)	Minus of 25-30%	Noleppa, 2012; von Witzke et al., 2011 Rockström et al. 2009		3.75-7.5m^2/d/cap	2.5-5m^2/d/cap

3.3 Threshold levels of selected indicators for the Nutritional Footprint

The eight indicators given in Table 1provide a detailed view on current food product components and their effect on environment and health, and a reasonable overview of the overall effect of foodstuff disregarding any further relation to each other.

The threshold levels for the different health and environmental-related indicators are given in Table 3. The values are based on the descriptions above (see section 3.2). The threshold levels allow the assessment of a diet per day, and accordingly, a whole set of dishes (breakfast, lunch, dinner and perhaps snacks incl. drinks).

Table 3: Threshold level of the nutritional footprint (per cap/day)

Health indicators	**Threshold level** (per day/cap) **Small impact**	**Medium impact**	**Strong impact**	**Environmental indicators**	**Threshold level** (per day/cap) **Small impact**	**Medium impact** **Strong impact**
Calorie intake (kcal)	<2000	2000-2500	>2500	Material Footprint (g)	<8000	8000g – 12000
Sodium (g)	<6	6-10	>10	Carbon Footprint (CO_2 eq) (g)	<2400	2400 – 3600
Content of dietary fibre (g)	>24	24-18	<18	Water use (l)	<1950	1950 – 2925
Saturates (g)	<20	20-30	>30	*Land use* (m^2)	*<3.75*	*3.75 – 5.625*
Impact levels	1	2	3		*1*	*2*

(Source: health: FDF 2013, DGE 2011, Max-Rubner-Institute 2008a, 2008b; environment: Lettenmeier et al. 2014, Macdiarmid et al. 2012, Rockström et al. 2009, Wirsenius et al. 2010)

In order to apply the concept to meals, the threshold levels have to be calculated for the unit of 'one meal' which also approaches everyday choices. Therefore, we propose the assumption that a lunch menu will provide 33 % of the daily intake and cut levels by 2/3. The effect levels are also illustrated in the tables in the last row to demonstrate the transfer of the units into the effect levels and to clarify which value illustrates which result (Table 4

). Such values thus standardise the inhomogeneous indicators to a comparable result - a meal which is rated with 600 kcal, will be equivalent to a value of '1' in the indicator of 'calorie intake'.

Table 4: Threshold level of the nutritional footprint (per meal) (source: own)

Health indicators	**Ranges of data** (per day/cap // per meal) **Small impact Medium impact Strong impact**			**Environmental indicators**	**Ranges of data** (per day/cap // per meal/cap) **Small impact Medium impact Strong impact**	
Calorie intake (kcal)	<670	670-830	>830	Material Footprint (g)	<2670	2670g – 4000
Sodium (g)	<2	2-3.3	>3.3	Carbon Footprint (CO_2 eq) (g)	<800	800 – 1200
Content of dietary fibre (g)	>8	8-6	<6	Water use (l)	<640	640 – 975
Saturates (g)	<6.7	<6.7-10	>10	*Land use* (m^2)	*<1.25*	*1.25 –1.875*
Impact levels	1	2	3		*1*	*2*

3.4 The integration of different indicators to one result

The first step of the Nutritional Footprint approach is the calculation of the relevant values for a certain meal or diet on the basis of the ingredients per 100 g and/or per portion. The contents of energy, sodium, dietary fibre and saturates can be taken from appropriate nutrition tables (Souci et al., 2008). To calculate the values for the environmental indicators, an appropriate database e.g. ECOINVENT was used. Secondly, the transfer of the results calculated into effect levels (1-3) has to be carried out. This is undertaken by using the established threshold level according to Table 4. If the calculation is undertaken for a single meal, the share of the meal in the nutritional value of the whole day has to be considered and allocated in an appropriate way (Table 3).

As a third step, the average of the four effect levels is calculated separately for the health and environment indicators (I) (Formula 2 and 3). As a result of this, the health and environment indicators are displayed in one effect level each. These effect levels have to be seen as decimal place holder.

Formula 2

$$NF_{health} = \frac{I_{h1} + I_{h2} + I_{h3} + I_{h4}}{\sum I_h} \qquad (2)$$

Formula 3

$$NF_{environment} = \frac{I_{e1} + I_{e2} + I_{e3} + I_{e4}}{\sum I_e} \qquad (3)$$

This step leads to an equitable ranking of the two sets of indicators in relation to each other. In the final step of the calculation, both effect level set are summed up and the average is determined again (Formula 4). This step is carried out to evaluate both indicator sets equally, and to present the result in one number.

Formula 4

$$NF = \frac{NF_{health} + NF_{environment}}{2} \qquad (4)$$

Therefore, the Nutritional Footprint is the average of the sum (shown in Formula 4) of the two calculation steps (Formula 2 and 3).

To establish a qualitative ranking, the result may also be classified in three written levels. The ranking of a *'low', 'medium'* and *'high'* effect can be identified. A low effect is obtained if the value lies in the range of 1 to 1.6; a medium effect is obtained for a value of 1.6 to 2.2. The Nutritional Footprint obtained is displayed as one value (e.g. 1.75/ medium effect) and a 'low' effect level is recommended without restrictions whereas a 'high' effect is recommended once or twice a week (inspired by German recommendation levels).

3.5 Application to different lunch meals

An example; when applying the Nutritional Footprint to a lunch, the relation of that meal to the nutrition of the whole day is a relevant question that may be answered differently in different countries. In this paper, it is assumed that a person may have a lunch which is quite rich in nutrients, so an average value of 33 % of the daily food intake which is covered by the lunch menu appears to be realistic when breakfast and dinner represent 25% and the remaining 17% are represented by two snacks per day (DGE, 2013).

A choice of classical lunch menus that are popular in Germany was selected:

- *Menu 1: Spaghetti Bolognese small salad (spaghetti)*
- *Menu 2: Classic curry sausage with chips and mayonnaise (sausage)*
- *Menu 3: Beef roll with potatoes and vegetables in red wine sauce (beef roll)*
- *Menu 4: Large mixed salad with baguette (salad)*
- *Menu 5: Breaded sea fish filet with remoulade sauce, potatoes and broccoli (fish)*
- *Menu 6: Vegetable lasagne (lasagne)*
- *Menu 7: Chili sin carne with bread (chili)*
- *Menu 8: Potato pancake with apple sauce (potato pancake)*

In order to reduce complexity and assuming that drinks have a minor effect in this case, beverages were excluded from the calculation. The results are presented in section 4.

4 Application of Nutritional Footprint to lunch meals: Results and discussion

4.1 The calculation of the Nutritional Footprint using suitable dishes

To demonstrate the applicability of the tool, eight selected dishes are displayed. In the first step of the calculation, the primary data had to be examined. Using adequate nutrition tables and databases such as ECOINVENT, the meal data was assessed (illustrated in Table 5). The challenge in this first calculation step was the calculation of the data from the available primary data, and then the allocation of results. While all the nutritional values were taken from nutrition tables, the environmental data for the specific ingredients was not always available, and so data of a similar ingredient had to be used (when there is no valuefor onions, the value for potatoes was used.

Table 5: Health and environmental data of the menus (source: own)

	Calorie intake (kcal)	Sodium (g)	Content of dietary fibre (g)	Saturates (g)		Material Footprint (g)	Carbon Footprint (g)	Water use (l)	Land use (m^2)
Spaghetti	881	3.6	8.4	9.4		2830	960	949.64	2.19-3.45
Sausage	1347	5.6	6.6	30.7		2010	590	805.50	1.78-2.16
Beef Roll	587	2.3	4.1	6.8		6760	2610	2128.01	5.14-9.13
Salad	494	1.6	6.7	4.6		1060	240	220.31	0.68
Fish	510	2.6	5.8	14.7		1680	620	819.63	0.66-0.68
Lasagne	402	2.7	6.8	6.5		1570	500	275.78	0.56-0.92
Chili	360	2.3	14.1	0.4		880	210	615.57	0.30
Potato pancake	1071	1.6	11.7	10.8		1180	250	182.98	0.49 – 0.55

In the second step of the calculation, the primary data is transferred into the effect levels, and then the average was obtained (Table 6

Table).

Table 6: Impact levels of the menus (source: own)

	Calorie intake (kcal)	Sodium (g)	Content of dietary fibre (g)	Saturates (g)	**Average Health**		Material Footprint (g)	Carbon Footprint (g)	Water use (l)	Land use (m^2)	**Average Environ-mental**
Spaghetti	3	3	1	2	**2.25**		2	2	2	3	**2.25**
Sausage	3	3	2	3	**2.75**		1	1	2	3	**1.75**
Beef Roll	1	2	3	2	**2**		3	3	3	3	**3**
Salad	1	1	2	1	**1.25**		1	1	1	1	**1**
Fish	1	2	3	3	**2.25**		1	1	2	1	**1.25**
Lasagne	1	2	2	1	**1.5**		1	1	1	1	**1**
Chili	1	2	1	1	**1.25**		1	1	1	1	**1**
Potato pancake	3	1	1	3	**2**		1	1	1	1	**1**

In the final step of both effect levels, sets are summed up and the average is again determined. Then, the Nutritional Footprint is calculated. This last step is used to provide and communicate the result in one number and one statement (Table).

Table 7: Final results of the estimation of the Nutritional Footprint (source: own)

Menu	Nutritional footprint [(subtotal health+subtotal env.)/2)]	Nutritional Footprint	Ranking
Menu 1 – Spaghetti Bolognese with a small salad	*[(2.25+2.25)/2]*	**2.25**	**High**
Menu 2 – Classic curry sausage with chips and mayonnaise	*[(2.75+1.75)/2]*	**2.25**	**High**
Menu 3 – Beef roll with potatoes and vegetable in red wine sauce	*[(2+3)/2]*	**2.5**	**High**
Menu 4 – Large mixed salad with a baguette	*[(1.25+1)/2]*	**1.125**	**Low**
Menu 5 – Breaded sea fish filet with remoulade sauce, potato and broccoli	*[(2.25+1.25)/2]*	**1.75**	**Medium**
Menu 6 – Veggie – zucchini - spinach - feta–lasagne	*[(1.5+1)/2]*	**1.25**	**Low**
Menu 7 – Vegan – Chili sin carne	*[(1.25+1)/2]*	**1.125**	**Low**
Menu 8 – Potato pancake	*[(2+1)/2]*	**1.5**	**Low**

The results for German lunch meals illustrate remarkable differences (Table 7). Compared to other studies, which assessed the effects of foodstuffs (Carlsson-Kanyama & Gonza, 2009; Jungbluth et al., 2010), the calculations applied here present results which are both comparable and able to be directly put into operation. Thus, a factor of 6 to 7 in the natural resource use of the different meals is classified.

The vegetarian and vegan choice show an indicator below 1,6 and, therefore, with a low effect level – or even a *sustainable level;* thus, these menus are suggested as preferable and recommendable for an everyday diet. The fish menu is at the level of a 'medium effect' and partially recommendable once or twice a week. All menus with a medium or large portion of meat are classified as less preferable and are rated with a 'high effect'. On viewing the results in detail, there are meals which have a great effect overall, but are, nonetheless, quite recommendable in a few indicators. This is recognisable by analysing the results; the beef rolls have a high effect on the environment in a health-related view, and the dish is partly recommendable.

4.2 Communicable display of the results

To guide decision-making processes based on the Nutritional Footprint, a comparative and transparent design to illustrate the results is necessary. As an essential aspect in the case whose results illustrate reduction recommendations, a design should not be too abstract and, at the same time, scientifically sound; it should provide an easy-to-understand tool to assist and guide consumers to a more healthy and eco-friendly diet.

Therefore, the Nutritional Footprint is designed in an easy to understand way (only ranges of 1 to 3) and tries to limit its results to one effect level. Different types of communication representing a complete view seem possible; these are inspired by the well-known efficiency classes A+++ to C, comparable to the EU energy label initiative (European Commission, 2014) or by a network structure as Rockström et al. (2009) propose (shown in and Figure 2). The Nutritional Footprint rating is illustrated by one number and also with the green or red footprint emblem in the centre. The graphic illustration also integrates detailed information by showing the sustainable level (green line) and the several effect levels of the indicators. The figures allow rapid comparison of two dishes with respect to the three colour rating system inspired by the traffic light rating system.

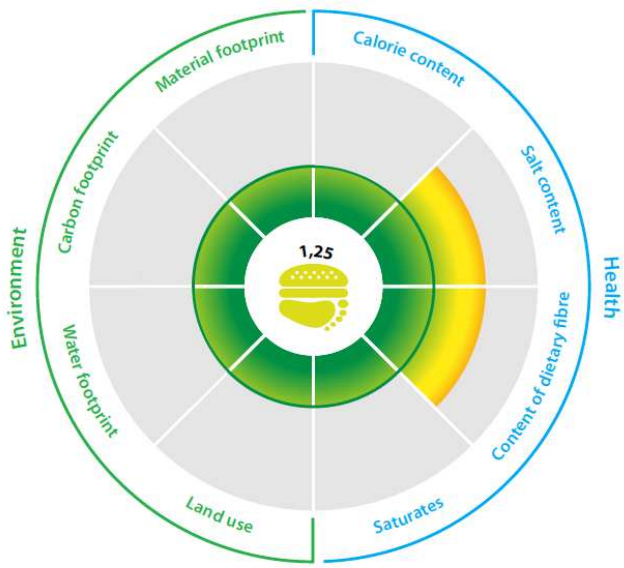

Figure 1: Communication example – Veggie lasagne (source: Wuppertal Institute)

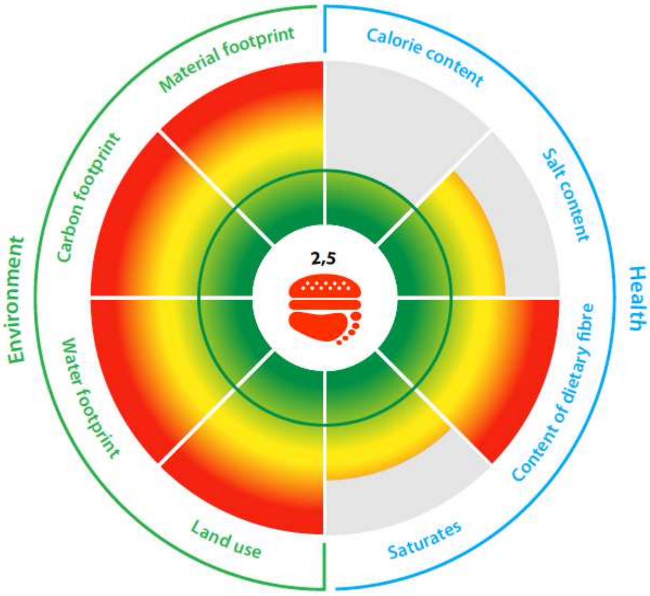

Figure 2: Communication example – Beef roll menu (source: Wuppertal Institute)

4.3 Short discussion - possibilities and limitations of the methodology

In this article, we have presented a new methodology of combining the health and the environmental dimension of food products in one footprint tool as a step to embed these highly relevant dimensions both in the field of science and in practice. A special purpose of our approach is to increase simultaneous awareness for both health and environmental issues accompanied by food production and consumption. We are aware of several weaknesses, intrinsic in this idea, which have to be discussed briefly.

Firstly, the question of the robustness of the approach considering the nutritional value of a single item or a menu is present. Of course, the value of a diet heavily depends on all food products consumed during a day or a variable time period. Therefore, the approach does not try to focus only on single food items, but calculates menus as a whole. If we consider the current guidelines – GDA (Guidelines Daily Amount) – the problem arises that these tools may only be applied to single food products, this means that the complete picture of an individual diet is still missing for the individual consumer. The Nutritional Footprint is in this case more flexible and also applicable to all menus per day and may also reflect some kind of "Environmental and Health Daily Amount". Nevertheless, the approach needs to be tested in different contexts. Furthermore, development to a weekly review or overview, or in a virtual application with smart phones, should be considered and examined in the future.

Returning to methodical limitations, it becomes obvious that in the first methodical deliberations, giving both dimensions equal status seems to be appropriate. However, it raises the question whether both dimensions have been/should be analysed to the same extent.

In this tool, the environmental indicators chosen to cover a wide range of effects overlap to a slight degree in two respects: Firstly, the material resources found in the Carbon Footprint are also part of the Material Footprint, but do not play a major role here. Secondly, there is a relation between land use and the biotic materials in the Material Footprint. However, as the land requirement of different biotic materials can differ greatly, we do not see a major problem of overlap here.

Further, we see a major shortcoming arising from the qualitative estimations made in the 'environmental dimension' (see Table 2). Further research is needed to validate the data and ranking levels. In addition, the selection of indicators is a general factor, which naturally influences the results. Especially with environmental indicators, there seems to be a recognisable tendency that if one environmental indicator turns 'red', the other ones will also do. This is not necessarily surprising because of a strong link between all indicators and the production processes of food stuffs. Considering this fact, a more intensive examination of this phenomenon is necessary, and perhaps a slight revision of the indicators cannot be excluded in the future.

Furthermore, it is not clear how consumers and companies may change their behaviour or management processes when working with the nutritional footprint. The tool could provide an understandable tool to support and guide consumers to a healthier and environmental friendly diet. Companies could influence consumers' decisions in the same direction if management and communication tools are adequate to support these decisions. More often, communication tools remain quiet indistinguishable to consumers, or do not address their needs. With the current discussion on sustainable development of companies in mind, the Nutritional Footprint can also be considered as an efficient and flexible management tool to improve internal information systems as this indicator includes more than one aspect of sustainable development. The tool could provide some kind of internal benchmark for product development. Above all, these ideas have not yet been empirically tested.

As a further limitation of the tool – we would emphasise that we only focus on the situation in industrial countries. Considering lifestyles and nutrition behavior in other countries, the relevance of this kind of tool could be different in pointing out the benefits of certain dietary targets (Young & Pellett, 1994).

4.4 Potential for the absolute reduction of natural resource use

Despite the fact that the effect of nutrition cannot be reduced too drastically (to a factor of 10 or more), and a minimumof food is necessary for individual health and fitness, people can live without using any means of transport (Lettenmeier et al., 2012b; Lukas et al., 2013a). Nutrition is an important field to encourage a sustainable transformation and to create an innovative strategy to inluence nutrition in the future; this reflects the need for a qualitative reduction. As we learn from the past, the communication and illustration of reduction potential and, in our case, of a sustainable diet often remain unclear and are, so far, usually not taken into by account in decision-making processes (Godemann & Michelsen, 2005) by consumer suppliers, and decision-makers. The Nutritional Footprint may guide reduction choices without only being focused on classical environmental and sustainability communication frameworks. Health and environmental perspectives are presented in an aggregated insight, and may influence decision making in relation to each other. In a more strategic implementation of this assessment tool, relevant new practices may be developed on the basis of actor-integrated experiments (Lakso & Lettenmeier, under review). For instance, catering establishments have extensive possibilities of developing and popularising low resource diets (Rohn et al., 2013).

In the long term, influencing nutrition choice may include the idea of having some kind of individual target values, and of attempting not to exceed a level of 1.8 in one menu. Knowledge of individual targets may inspire choice and a person may have to go without a meal; this is similar to the concept of the well-known and quite successful concept 'Weight Watchers' (Weight Watchers, 2014). A related approach may be considered and implemented in companies, especially meal suppliers. They may internally reflect reduction levels and set benchmarks for their own products.

5 Conclusions and outlook

The field of nutrition represents an opportunity for implementing reduction potential. It covers a huge range of environmental, public health and cultural implications, which are important for a strategy of dematerialisation. While producers and consumers are well able to take immediate decisions to decrease their effects, sustainable decisions can be made at any time and fast change may be envisaged in this field.

With the tool in question – it connects environmental perspectives and health perspectives – many results are possible. As in several fields of sustainability science, the problem is that the environmental debate remains on an abstract level and is not perceived as a local or individual problem. The integrated health perspective here has a direct relation to the individual and thus appeals to a personal decision level. Unfortunately, the concept has not been widely implemented in everyday life. Thus, it is not possible to evaluate reduction potentials in a quantitative way. The advancement or redefinition of indicator sets in the future might be a necessary step in the integration of indicators which mainly reflect respective animal-based protein or biodiversity. Moreover, the suggestion of integrating the economical perspective in the approach is likely at present.

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Appendix 1

Table A1: Environmental indicators, status quo and targets for a sustainable diet in the future (source: own)

Topic	Indicator	Scenario	Recommendation/ Impact	
Qualitative recommendation (Overall perspective)				
Nutrition ecology	Qualitative; Material Footprint	today	Food should be... - predominantly plant derived, - originate from organic farming - produced regionally and seasonally - minimally processed - ecologically packaged - food trade should be fair - tastefully prepared plus - Waste Prevention - Avoidance of Car Trips for small amount of food	
Healthy and sustainable diet	qualitative	today	• - 83 % meat and meat products • -32 % milk and dairy products • +18,5 % fruits and vegetables • +4 % pasta, potatoes, rice and pulses	
Carbon Footprint				
Sustainable diet target	Carbon footprint	2050	Reduction of 70%	
Sustainable diet target	Carbon Footprint	2012	Reduction of 36% GHGEs	
Material Footprint				
			Value kg/(cap*a)	**Value kg/(cap*d)**
Present Finnish diet	Material	2005	5900	16.2

	Footprint			
Present Indian diet	Material Footprint	2007	2500	6.8
Resource cap target	Material Footprint	2050	3000	8.2
Land use				
			Value	
Global agricultural land use global	Land use	2030	4,18 billion ha (25 % less meat consumption and less food waste)	
Land use and food consumption	Land use	2012	Minus of 25-3% ($5\text{-}10m^2$/cap/d) (2900 m^2 per capita and year in Germany. The global target is 2000 m^2 per capita and year.)	
Global overall land use	Land use	-	Minus of 25-30% (from 20 m^2/cap/d)	
Global cropland	Cropland	2030	0,2 m^2/cap/d	5,5 m^2/cap/a
Water consumption				
			Value /(cap*a)	
Water footprint in developed countries	Water use	2030	Reduction by 25 %	
Water footprint sustainable scenario	Water footprint	2050	-2 % compared to 2000	
Water footprint – current status quo	Water footprint	1996-2005	1385 m^3 // 92 % related to agricultural products	