Peer-reviewed | Manuscript received: July 20, 2014 | Revision accepted: October 01, 2014

The nutritional footprint – An assessment tool for health and environmental effects of nutrition

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Summary

It is generally accepted that if further progress is to be made towards a societal transformation in the direction of sustainability, the food sector will have to be an important field of action, as it has major environmental consequences – from effects in production, processing, consumption and disposal. As nutritional habits not only induce ecological effects, but also have consequences for consumer health, concepts must be developed that combine ecological and health indicators – but such concepts are scarce. This problem is addressed in the present article. This introduces the instrument of the "nutritional footprint", an innovative concept that combines four core indicators in each of the two dimensions.

Consumers who use this concept obtain an overview of the environmental and health consequences of their nutrition. The nutritional footprint can also be used by companies to administer internal data sets, carry out benchmarking and to improve their external communication.

Key words: nutritional footprint, health, environment, sustainable nutrition, consumer communication, resource efficiency

Citation:
Lukas M, Scheiper ML, Ansorge J, Rohn H, Liedtke C, Teitscheid P (2014) The nutritional footprint – An assessment tool for health and environmental effects of nutrition. Ernahrungs Umschau 61(11): 164–170

This article is available online:
DOI: 10.4455/eu.2014.028

Introduction – Thinking about nutrition and the environment

Sustainable development includes the objective of reducing the use of resources and should be implemented at all levels of everyday life, including consumption, politics and industry [1]. At the level of private consumption, there are intricate possibilities for improvements in mobility, building and housing, and nutrition [2]. Nutrition is a particularly interesting field of action, as two different points of view are combined. Firstly, there is the subjective individual dimension of individual health and, secondly, the societal debate on future forms of nutrition and the ecological consequences of food production. What is interesting is that both nutritional and environmental sciences suggest that food selection should be modified [3, 4]. There are some products (e.g. meat and meat products) which are thought to be damaging to health when consumed at excessive levels [5–8]. There are other products (e.g. milk and milk products) which should be consumed at adequate, but not excessive, levels [9–11]. Environmental scientists are increasingly coming to the conclusion that the consumption of both these groups of products should be reduced for ecological reasons. In this context, the instrument of the nutritional footprint follows the goal of improving the presentation of these correlations.[1] In the following sections, the methods employed in this concept are explained. Examples of its use are presented and briefly discussed.ert.

Background – the scientific principles

Many international studies have described the links between primary food production and the environ-

[1] The present article concentrates on the health and environmental consequences of individual health. In the longer term, it will be attempted to extend the instrument to cover the social and economic dimensions, so that it is properly anchored in the concept of sustained development.

mental stress this causes [9–11]. For example, MACDIARMID et al. [3] carried out an analysis of the environmental effect of individual food groups. They showed that, if nutritional style is modified to enhance ecological tolerance, it may also become healthier. Moreover, it may be implemented without excessive costs and without totally dispensing with meat. For the sake of simplicity, this and many other studies use the core indicator "greenhouse gas emissions" to calculate the environmental effects, even though the concept of sustainable nutrition demands something more detailed, e.g. indicators, solutions and recommend actions which are more comprehensive and which are easier for the consumer to understand. One such example would be to consider the social implications [7]. As a consequence, scientific recommendations on sustainable nutrition are still at a relatively abstract level and have virtually no influence on the consumer's normal nutrition. This may be linked to a recognised problem in environmental psychology, namely that just knowing about available sustainable nutrition does not lead to changes in behaviour or to the propagation of an environmentally friendly and healthy nutritional style [12]. Thus, the available nutrition for specific target groups should be planned to be more sustainable. In parallel, innovative ways of communicating information must be identified, as the consumer cannot assess the "sustainability quality" of foods on his own [13]. It is therefore more necessary than ever to have an instrument that implements these requirements and also portrays the limits of sustainable nutrition.

Calculating the nutritional footprint

As is conventional in life cycle analyses [14], the nutritional footprint is calculated to cover all phases of the production chain, from the generation of raw materials, through processing and use and up to disposal. Thus, the process for determining the nutritional footprint may be split into three essential working steps:

1. Calculating the relevant environmental and health factors, using a selected set of indicators: On the basis of relevant scientific data, environmental indicators and health indicators are calculated (e.g. energy content [kcal] per meal; water consumption per meal).
2. Converting the results into numerical parameters, using the three step system as developed.
3. Calculating the nutritional footprint by adding the numerical parameters and averaging.

Converting the results into numerical parameters is a scientifically valid procedure that gives a value for the footprint that is easy to communicate. Thus, the results are presented as a single figure; the underlying idea is to communicate the results as clearly as possible, in a way that is equally accessible to the consumer and to the company manager. The core of the instrument is then a newly developed indicator set and a newly developed threshold assessment.

Selecting the indicators

Relatively well known, scientifically based and familiar indicators are selected, which are intended to cover a broad spectrum of effects on the environment and on health. During the development of the concept, the first step was to examine relevant indicators from previous scientific publications.

The research on indicators identified nine highly relevant health indicators and eight highly relevant environmental indicators. Both indicator sets were selected on the basis of their scientific relevance. Other important selection criteria were data quality and data availability [15].

For the sake of practicability, four "core indicators" were selected for each set. The four core health indicators included two negative indicators (salt and saturated fatty acids), one positive indicator (dietary fibre content), as well as the indicator: energy content. Taken together, these four indicators give a broad overview of the effects, without going into excessive detail (e.g. selection of individual vitamins or minerals) (◆ Table 1). This selection also considered current communication concepts, such as the food traffic lights[2], as implemented by the British Food Standards Agency (FSA) [15] or the "Guideline Daily Amounts" (GDA)[3] [16].

Four of the eight environmental indicators were selected. These were the central areas affected by primary production – biotic/abiotic resources, greenhouse gas emissions, water use and land use – and provide a simplified image of the environmental factors

Deriving the ranks

Deriving the ranks is an essential component of the nutritional footprint concept. The ranks describe the extent to which the specific value of an indicator (e.g. salt content in a meal, water consumption from the production of a meal) has a negative effect on health or on the environment. The classification was made on the basis of an assessment of relevant scientific recommendations and is orientated towards a classical three step scale (small, medium and strong impact). The specification of the individual steps of the health indicators was orientated towards the

[2] The British food traffic lights include the indicators "fat", "salt", "sugar" and "saturated fatty acids"[15].

[3] The core indicators of the GDA include "kilocalories", "sugar", "fat", "saturated fatty acids" and "salt" [16].

Health Indicators	Environmental Indicators
energy (kcal)	material footprint* (g)
salt content (g)	carbon footprint (g)
dietary fibre content (g)	water consumption (L)
saturated fatty acids (g)	land use (m²)

Tab 1: **Indicators of the nutritional footprint**

* The material footprint is the sum of all necessary resources needed during the complete life cycle of a product [7]. In the present article, this is taken to mean the sum of all abiotic and biotic materials.

current recommendations of internationally and nationally active organisations (World Health Organisation [WHO] or German Nutrition Society [DGE]). However, specifying the individual levels for the environmental indicators turned out to be a challenge. The reason for this is that the environmental indicators have not yet been subjected to a final positive or negative assessment. In other words, unlike in nutritional science, there are no established recommendations (e.g. for environmentally friendly water consumption).

For the health indicators, the recommended supply values were classified as "small impact" (slight negative effect on health). However, the current consumption values of the German population were rated as "strong impact" (large negative effect) [5]. The reason for this is that the mean actual values for supplied energy and saturated fatty acids in Germany do not fulfil the recommendations – mainly due to the excessive consumption of animal products [5]. The scientific recommendation is made that it should be attempted in the long term to adapt these (unhealthy) habits to the recommendations. In contrast, the environmental sciences do not have recourse to such a collection of recommended actions. For this reason, the classification of environmental indicators was supported by the prognoses of selected scientific publications in this area.

Lettenmeier et al. [7] refer very specifically to the field of nutrition and recommend, for example, a reduction by ca. 30–50 % in resource consumption (material footprint) in production and consumption, in order to achieve a significant reduction in the negative effects of nutrition. One way of achieving this objective would be to strive to obtain a vegetarian diet and to avoid food waste. Similar estimates can be made for carbon footprints, water consumption and land use. In the qualitative assessment of environmental indicators it was therefore assumed that the current consumption of resources should be reduced by 50 %, if at all possible, in order to achieve the lowest possible negative environmental effect in the long term. This objective was taken as the basis for the "small impact" level. This means that, if resource consumption is in fact reduced by 50 %, there will be fewer undesired adverse negative effects on the environment.

The range of "medium impact" is currently undefined, as there have not yet been any studies that unambiguously define a target value and the corresponding graduations. A "strong impact" was defined as when the current consumption values were reduced by only 15 % (or less). All assessments are based on a long-term reduction in resource consumption.

The calculations here employed

Health Indicators	Classification of the values (per meal/person)			Environmental Indicators	Classification of the values (per meal/person)		
	small impact	*medium impact*	*strong impact*		*small impact*	*medium impact*	*strong impact*
energy (kcal)	< 670	670–830	> 830	material footprint (g)	< 2 670	2 670–4 000	> 4 000
salt supply (g)	< 2	2–3.3	> 3.3	carbon footprint (CO_2 eq) (g)	< 800	800–1 200	> 1 200
dietary fibre content (g)	> 8	8–6	< 6	water consumption (L)	< 640	640–975	> 975
saturated fatty acids (g	< 6.7	< 6.7–10	> 10	land use (m²)	< 1.25	1.25–1.875	> 1.875
Ranks	**1**	**2**	**3**		**1**	**2**	**3**

Tab 2: **Classification per meal and person (2,000 kcal)**

generic values. These may deviate from the situation in the real world, particularly when it is remembered that there is a wide variety of culture procedures in the primary production of food products. The material footprint, carbon footprint, water consumption and land use may fluctuate over a relatively large range; that depends on data quality and precision.[4]

Values of the ranks

The levels shown in ◆ Table 2 refer to the input of the listed indicators per meal. It was assumed that one third of the daily requirements (2,000 kcal) are covered by a classical hot meal and this was specified as a measurement unit for this calculation. Thus, for example, a meal has a "small impact", if the values are lower (or, for dietary fibre, higher) than a third of the recommended daily supply. There is a "strong impact", when the values are greater than one third of the current daily consumption of the German population. The last line in the table shows the "rank" in the numerical sequence "one-two-three". This grouping is used as the basis for the calculation of the nutritional footprint.

Calculating the nutritional footprint

In the first step, the data on the nutritional value of the dishes are calculated (see, for example [18]) and converted to the ranks "one-two-three" (corresponding to "small", "medium", or "strong impact"). The environmental indicators are calculated with the appropriate databases, e.g. Ecoinevent or Gabi. We also have recourse to our own unpublished data sets on production chains.

The individual ranks "one-two-three" of the four indicators are then used to calculate the averages of the environmental or health indicators (formulas 1 or 2), giving an independent value for each set of indicators[5].

Formula 1

$$NF_{health} = \frac{I_{h1}+I_{h2}+I_{h3}+I_{h4}}{n}$$

Formula 2

$$NF_{environment} = \frac{I_{e1}+I_{e2}+I_{e3}+I_{e4}}{n}$$

In the last step, the two indicators are added up and a mean formed (formula 3). Thus the two indicator sets have the same weight.

Formula 3

$$NF = \frac{NF_{health}+NF_{environment}}{2}$$

The nutritional footprint then represents the mean sum of the previous calculation steps.

In addition to the absolute and quantitative value, qualitative classification is also employed. A value of less than 1.65 is rated as low (low negative effect on environment or health), a value between 1.65 and 2.3 as medium (intermediate effect) and a value above 2.3 as high (strong effect).

These thresholds are based on the fact that the maximal value for the nutritional footprint is 3 and the minimal value 1. This range is split into three equal sections to reflect three different levels. Values under 1.65 count as low impact. Values from 1.65 to 2.3 count as medium impact and values above 2.3 as high impact.

Example: Calculation of five selected menus

To demonstrate the theoretical derivation and calculation of the nutritional footprint, this will now be applied to five selected menus. The menus were selected after inspecting current consumer trends in the context of Food for Eating Out (AHV).

- Burger menu[6]: burger with double beef patty, with chips and cola
- Chili sin carne menu: vegan chili sin carne with white bread and apple juice with mineral water
- Lasagne menu: vegetarian lasagne with salad side dish and apple juice with mineral water
- Meat roll menu: meat roll with red cabbage side dish, potatoes and water
- Wrap menu: wrap with chicken and salad side dish, apple and water

In the first step, the calculated values and the corresponding numerical levels of the menu are shown (◆ Table 3).

As ◆ Table 3 shows, the individual real values (e.g. for dietary fibre content and carbon footprint) are first calculated, and then converted to the numerical parameters.

◆ Table 4 shows the final result (nutritional footprint) from the combination of the health and environmental indicators.

[4] There are few significant differences between biological and conventional agriculture in the ranges in the material and carbon footprints (depending on the type of calculation and data quality). For example, the extensive cultivation procedure in biological agriculture often brings lower yields. Depending on the method of calculation and system limits, this tends to give poorer results. However, if external factors are considered, this often gives a better result for biological agriculture. Increased sustainability in agriculture cannot be discussed on the basis of these four selected indicators in isolation.

[5] NF = total nutritional footprint; I_h= health indicator (including dietary fibre content); I_e = environmental indicator (including material footprint)

	Weight/Meal plus (drink)	Energy (kcal)	Salt intake (g)	Dietary fibre content (g)	Saturated fatty acids (g)
Burger menu	400 g (500 mL)	1 335	2.9	9	11
		3	2	1	3
Chili sin carne menu	580 g (200 mL)	466	2.6	16	0.5
		1	2	1	1
Lasagne menu (veg.)	570 g (200 mL)	550	3.0	8.6	7.1
		1	2	1	2
Meat roll menu	590 g (200 mL)	697	2.4	5.9	6.8
		2	2	3	2
Wrap menu	445 g (500 mL)	510	3.1	6	4
		1	2	2	1

Tab. 3: **Overview of interim results** (absolute values per meal and ranks)

Discussion

The calculated numerical values are easy to understand and provide a good overview of the ecological and health consequences of the menus examined. The objective is to communicate a parameter that is transparent and relevant to normal life, as the values are not based on individual ingredients, but on the whole meal.
It is striking that the beef-based dishes – the burger and meat roll menus – have relatively high environmental effects, with intermediate health effects. In contrast, chili sin carne as a vegan dish, has low negative environmental and health effects. The results reflect current scientific knowledge and make it clear that dishes with a high proportion of animal products – particularly red meat – have greater negative effects on both the environment and on health. Even though the wrap menu included chicken, its results were better, as it only contained 60 g meat and most of the other ingredients were vegetables.
Thus, the nutritional footprint clearly and pithily combines the goals of supporting health and reducing environmental stress. In the long term, social and economic dimensions have be integrated into the concept, as an approach towards developing an instrument for analysing sustainable menus. The restriction of the dimensions to four core indicators must also be critically considered. The same applies to the use of a single figure for the results. In the present study, this was used as an initial approach and the first attempt to combine ecological and health factors into a single simple parameter.

[6] The composition of the burger and wrap menus is based on the menus from McDonald's Deutschland Inc.This is also the reason that the size of the drink in the menu is different (500 mL) (◆ Table 3). These differences were not adjusted, as the dishes are normally served and consumed in this form. Similarly, the three other menus were adapted to the settings of eating out (works canteen, school canteen).

Menu	Calculation of nutritional footprint	Final result – nutritional footprint	Qualitative ranking
Burger menu	(2.25 + 3) : 2	2.625	*high*
Chili sin carne menu	(1.25 + 1) : 2	1.125	*low*
Lasagne menu	(1.5 + 1) : 2	1.25	*low*
Meat roll menu	(2.25 + 3) : 2	2.625	*high*
Wrap menu	(1.5 + 1.25) : 2	1.375	*low*

Tab. 4: **Final result**

Numerical evaluation health indicators	Material footprint (g)	Carbon footprint (g)	Water consumption (L)	Land use (m²)	Numerical evaluation environmental indicators
	4 160	1 470	1 070.53	2.85–4.51	
2.25	3	3	3	3	3
	1 000	240	639.38	0.32	
1.25	1	1	1	1	1
	2 170	660	361.63	0.81–1.26	
1.5	1	1	1	1	1
	6 980	2 670	2 172.84	5.22–9.21	
2.25	3	3	3	3	3
	2 080	670	595.07	1.5–1.78	
1.5	1	1	1	2	1.25

Communicating the results

During this research project, an integrative presentation was developed for the nutritional footprint (◆ Figure 1). This portrayal presents the overall result as a numerical value, together with block diagrams for the individual indicators.
The colour labelling is based on traffic lights and makes it easy for the consumer to see whether the dish or product is favourable for health or the environment. The labelling applies to the average size of a portion of the dish. The nutritional footprint is therefore particularly suitable for evaluating restaurant menus or convenience products, e.g. at point of sale or in canteens. Companies working with the nutritional footprint can exploit the possibility of individual evaluation to identify the ecological and health weak point in their products.

Conclusion

The nutritional footprint is an innovative concept that can influence sustainability transformation processes in the important area of nutrition. This instrument addresses the problem that environmental discussions tend to be highly abstract. Moreover, in contrast to health issues, they often have no apparent direct relevance for the individual. In the long term, the objectives of influencing the processes of change and of supporting the paradigm of sustainable nutrition can be approached by integrating social and economic dimensions into the indicator set.

Acknowledgements: This article was developed with financial support in the project "Socio-economic practices of sustainable development in the new industrialization" and performed with the ITMO University. (Project Reference: Grant 074-U01) (Government of the Russian Federation).

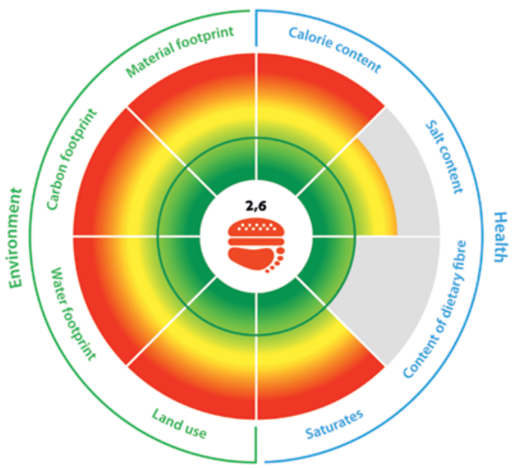

Fig. 1: **Portrayal of the Nutritional Footprint** example burger menu (Source: Wuppertal Institute)

Conflict of Interest
The authors declare no conflict of interest according to the guidelines of the International Committee of Medical Journal Editors.

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References

1. *Rockström J, Steffen W, Noone K et al. (2009) Planetary boundaries : Exploring the safe operating space for humanity. Ecology and Society 14 (2): 32*
2. *The nutritional footprint – assessing environmental and health impacts of foodstuffs. In: World Resources Forum. Davos. URL: www.worldresourcesforum.org/files/WRF2013/Full Papers/Lukas,Liedtke&Rohn_WRF2013.pdf Zugriff 08.07.14*
3. *Macdiarmid JI, Kyle J, Horgan GW et al. (2012) Sustainable diets for the future : can we contribute to reducing greenhouse gas emissions by eating a healthy diet ? Am J Clin Nutr 96: 632–639*
4. *Deutsche Gesellschaft für Ernährung. 12. Ernährungsbericht. Bonn (2012)*
5. *Die Nationale Verzehrsstudie - Ergebnisteil 1 und 2. Karlsruhe. URL: www.mri.bund.de/fileadmin/Institute/EV/NVSII_Abschluss bericht_Teil_2.pdf Zugriff 08.07.14*
6. *Leitzmann C, Wirsam B (2011) Klimaeffiziente Ernährung. Ernährungs Umschau 58: 26–29*
7. *Lettenmeier M, Liedtke C, Rohn H (2014) Eight tons of material footprint – Suggestion for a resource cap for household consumption in Finland. Resources (3): 488–515*
8. *Mancini L, Lettenmeier M, Rohn H et al. (2012) Application of the MIPS method for assessing the sustainability of production-consumption systems of food. J Econ Behav Organ 81(3): 779–793*
9. *Mekonnen MM, Hoekstra AY (2011) The green, blue and grey water footprint of crops and derived crop products. Hydrol Earth Syst Sci 15:1577–1600*
10. *Liedtke C, Baedeker C, Kolberg S et al. (2010) Resource intensity in global food chains: the Hot Spot Analysis. British Food J 112 (10): 1138–1159*
11. *Sabaté J, Soret S (2014) Sustainability of plant-based diets: back to the future. Am J Clin Nutr 100 (Suppl 1): 276–382*
12. *Matthies E (2005) Wie können PsychologInnen ihr Wissen besser an die PraktikerIn bringen? Vorschlag eines neuen integrativen Einflussschemas umweltgerechtes Alltagshandelns. Umweltpsychologie 9 (1): 62–81*
13. *Teitscheid P (2013) Auf dem Weg zu einer nachhaltigen Ernährung. Ernährungs Umschau 60: 66–71*
14. *Ritthoff M, Rohn H, Liedtke C (2002) Calculating MIPS - resource productivity of products and services (No. 27e). Wuppertal. Retrieved from http://epub.wupperinst.org/frontdoor/index/index/docId/157 Zugriff 09.09.14*
15. *Sacks G, Rayner M, Swinburn B (2009) Impact of front-of-pack 'traffic-light' nutrition labelling on consumer food purchases in the UK. Health Promotion International 24: 344–352*
16. *Die Guideline Daily Amounts. URL: www.aid.de/downloads/gda_kennzeichnung.pdf Zugriff 31.05.14*
17. *Schmidt JH (2008) Development of LCA characterisation factors for land use impacts on biodiversity. J Clean Prod 16: 1929–1942*
18. *Souci SW, Fachmann W, Kraut H. Die Zusammensetzung der Lebensmittel. MedPharm (2008)*

DOI: 10.4455/eu.2014.028