Defining a nutritionally healthy, environmentally friendly, and culturally acceptable Low Lands Diet

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ABSTRACT

Our study quantifies the historical Dutch diet of 80 years ago, based on a cultural history research. We calculate the greenhouse gas emissions (GHGE) and land use (LU) of this diet, using actual LCA data for 206 most consumed products, and the health score, based on ten nutritional characteristics. In order to meet the current requirements, we optimize this diet for adult males using linear programming. We compare the diet with the present Dutch, Mediterranean and New Nordic Diet. An optimized Low Lands Diet has the same healthy nutritional characteristics as the Mediterranean and the New Nordic Diet, and results in a lower environmental impact. The diet consists mainly of products with a high nutrient density. An adaptation of this historical diet, which fits more into the eating habits, climate and agricultural tradition of the Low Lands, is assumed easier to achieve than a transition into a foreign European diet.

Keywords: Greenhouse gas emissions, historical Dutch diet, New Nordic Diet, linear programming, health impact

1. Introduction

The present Dutch diet is not in line with the dietary guidelines (Health Council 2006; WHO 2003). Regarding the health impact, the diet has an unfavorable fatty acid composition, which increases the risk of cardiovascular diseases. Besides, only 5% of the Dutch population adheres to the recommended fatty acid composition through fish consumption. Insufficient consumption of fruit and vegetables increases the risk of coronary heart diseases, stroke and some forms of cancer (lung, breast and stomach cancer) (Van Kreijl et al. 2006). The increased intake of energy-dense foods that are high in fat has resulted in a worldwide doubling of obesity since 1980. In The Netherlands 30% in the population aged 4 years and older are moderately overweight. Another 10% has severe overweight (obesity) (CBS, 2012). Overweight and obesity are major risk factors for a number of chronic diseases, including diabetes, cardiovascular diseases, and cancer. The unfavorable dietary composition contributes approximately twice as much to the total mortality as overweight: 10% versus 5% of the annual deaths in the Netherlands (Van Kreijl et al. 2006).

Current trends in food production and consumption are considered unsustainable. For example, approximately one-third of human influence on greenhouse gas emissions (GHGE) and land use (LU) is related to our diet and the food chain (Vringer et al. 2010). The average Dutch diet is less sustainable, in terms of GHGE and LU, than eating according to the Dutch dietary guidelines. Further improvements are within reach, we conclude in a recent paper (Van Dooren et al. 2014a).

To reach these improvements, policy makers are exploring the possibilities to develop guidelines for healthy diets that are also low in environmental impacts (Health Council 2011). These guidelines are still qualitative and quite general. The aim of this paper is to define more in detail a nutritionally healthy, environmentally friendly and culturally acceptable diet for the Low Lands. In theory it is possible to define an optimal diet, according to criteria both for health and environmental impact (Van Dooren et al. 2014b). However such optimized diet may have difficulties being broadly accepted by consumers. Therefore, we seek dietary solutions that fit into the historical and cultural context, and climate of the Netherlands and Flanders, called the Low Lands Diet[1]. We build on the experience gained by scientists who recently explored and defined the Mediterranean diet (MD) (Bach-Faig et al. 2011; Fidanza and Alberti 2005), and the 'New Nordic Diet' (NND) (Bere and Brug 2009; Bere and Brug 2010; Hahnemann 2010; Mithril et al. 2013; Mithril et al. 2012; Uusitupa et al. 2013). Our hypothesis is that through clever combinations we can define an optimal diet for the Low Lands of Europe, comparable to the MD and NND.

[1] *Low Lands refer to the Rhine-Meuse delta, mainly characterized by fertile flat land at North Sea level, a temperate climate, and a sober, tolerant, former Calvinist, Dutch speaking culture.*

2. Methods: approach

In order to substantiate our hypothesis and reach our aim, we first describe our method to quantify the nutritional health (section 2.1) and environmental impact of different diets (2.2). To calculate the environmental impact, we need the GHGE and LU data of food products. Reliable data are sourced; using actual Life Cycle Assessments for 206 most consumed Dutch products (2.3). We apply this calculation methods to diets found in literature (2.4).

2.1. Calculating the Health Score

The health benefits and impacts of diets are highly complex and under continual debate and not easy to quantify. Insight in and impact of different indicators are relative and change overtime. Fortunately, different health organizations such as WHO (2003), World Cancer Research Fund, RIVM, and the Dutch Health Council (2006) have been using more or less the same indicators. The existing concept of the US Healthy Eating Index (Kennedy et al. 1995) to quantify overall diet quality is useful, but not directly applicable to Europe due to differences in cultural habits (serving sizes) and nutritional guidelines. Therefore, we developed a related score relevant to the European context. This Health Score is described elsewhere (Van Dooren et al. 2014a). The Dutch Health Council (2006) has translated and quantified the ten indicators towards a recommended intake in the Dutch population. These indicators reflect preventive factors for different food-related diseases, such as obesity, heart disease and cancer. We calculate the scores of diets, based on the ten indicators, with the following formula: Eq.1.

Health Score = (g vegetables/200g + g fruits/200g + g fiber/30g + g fish/37g + 30 en%/en% total fat + 10 en%/en% saturated fat + 1 en%/en% trans-fat + 10 en%/en% free sugars + 6 g/g salt + 2500 kcal/kcal energy)/10 **Eq. 1** (Van Dooren et al. 2014a)

2.2. Calculating the Sustainability Score

In 2010 the FAO agreed upon a definition for sustainable diets (FAO 2010): *Sustainable Diets are those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations.* 'Low environmental impacts' –as part of the definition of sustainable diets- need to be quantified using different parameters. Energy use and GHGE can be considered good proxies for this total environmental impact (Dutilh and Kramer 2000). LU and land use change are good proxies for loss of biodiversity (Pereira et al. 2010). In the score, we therefore used LU and GHGE as indicators to quantify -in relative terms- the environmental impact of the diets, because together they cover at least the top 4 of the impacts identified by Rockström et al. (2009). Our Sustainability Score is defined in an earlier study (Van Dooren et al. 2014a). We used the 2020 European Commission goal of a 20% GHGE reduction in the food chain (compared to 1990) as a reference value, although it is a political, arbitrary choice. The GHGE of the Dutch diet in the 1990s was 4.09 kg CO_2eq/day; the 2020 goal is 20% lower or 3.27 kg CO_2eq/day. This level was allocated a score of 100.

For LU we have no single reference value. The present LU in the Netherlands, according to the WWF (2012), is 3.20 global hectares. Publications about the ecological footprint (WWF 2012) suggest that the worldwide available biocapacity calculated in LU is 1.78 global hectares, which is 44% below the present use. We used as a reference a 44% reduction in the food chain applied for LU. From 5.34 m^2*year/day (the LU of the 1990s Dutch diet) to 2.97 m^2*year/day is a 44% reduction. This value was indicated as 100. The Sustainability Score was defined as the average of the GHG and LU score per diet. The score was calculated with the following formula: Eq.2.

Sustainability Score = (3.27 kg/ kg CO_2eq GHG + 2.97 m^2*year/ m^2*year LU)*100 /2
Eq. 2 (Van Dooren et al. 2014a)

2.3. Life Cycle Assessment of food products

Our calculation of GHGE and LU for the most consumed products in the diets is based on Life Cycle Assessment (BSI 2008; JRC 2010). The LCA methodology for agricultural products we use is described in 'The Agri-footprint method; Methodological LCA framework, assumptions and applied data, Version 1.0' (Blonk et al. 2011). The life cycle boundary is from raw materials acquisition and natural resources to final disposal, including food waste, and some estimate of energy use for cooking and preparation at home. In LCAs of agricultural products, the main contributors to the end score are GHGE, LU, and fossil energy use (Sevenster et al. 2010). Two of these are covered. In the scope of this study, it was not possible to carry out an extensive assessment to determine standard deviations for the parameters. LCA experts assume a general uncertainty of 10% to 20% in the results (Blonk et al. 2011).

2.4. Literature research

Using literature research, we define European examples of diets which are mentioned as both nutritionally healthy and low in environmental impact. We focus on recent publications exploring the Mediterranean and New Nordic Diets. In order to compare these diets with the Low Lands Diet, we quantify also the historical Dutch diet of about 80 years ago (1900-1940), based on a cultural history research (Jobse-Van Putten 1995; Van Otterloo 1990).

3. Results

3.1. Defining the Mediterranean Diet (MD)

The MD has been the subject of many studies (Trichopoulou et al. 2005) and we have previously studied this diet (Van Dooren et al. 2014a). The MD is characterized by a high intake of vegetables, pulses, fruits, and cereals (in the past largely unrefined); a moderate to high intake of fish; a low intake of saturated lipids but high intake of unsaturated lipids, particularly olive oil; a low to moderate intake of dairy products, mostly cheese and yogurt; a low intake of meat; and a modest intake of alcohol, mostly as wine (Willett et al. 1995). The best quantitatively defined description of this historical diet is probably published by (Fidanza and Alberti 2005).

Harvard Medical School further translated the dietary pattern into a more Western, culturally acceptable, diet with concrete recommendations (Willett 2001) and Willett published together with Oldways in 2009 the Mediterranean Diet Pyramid (www.oldwayspt.org). A consensus meeting recently updated the Mediterranean diet pyramid (Bach-Faig et al. 2011). Buchner et al. (2010) published the Double Pyramid and compared the ecological footprint of foods with their health-related position in the pyramid. They concluded that foods that are recommended for health reasons generally have lower environmental impacts as well. In contrast, foods with lower recommendations are those with a higher environmental impact. In an earlier climate diet study the Willett diet was also evaluated (Stehfest et al. 2009). In Table 1 we compare three ways to quantify the MD. The last column has been used for this study.

Table 1. Quantification of the Mediterranean Diet.

(Fidanza and Alberti 2005) *(% of energy)*	**(Bach-Faig et al. 2011)** *(servings (s))*	**(Van Dooren et al. 2014a)** *(grams per day)*
cereals (48%–52% of energy)	1-2 s pref. wholegrain every meal	210 g wholegrain bread
		100 g grain products (pasta)
extra virgin olive oil (14.5%–16.6%)	olive oil every meal	45 g vegetable oils
vegetables (5%–7%)	>= 2 s every meal	300 g mainly fresh vegetables
	potatoes <= 3s weekly	25 g potatoes
pulses (4.4%–6.6%)	>= 2 s weekly	75 g pulses
fruit (2.0%–2.6%)	1-2 s every meal	250 g fruits
fish (1.6%–2.0%)	>= 2 s fish/seafood weekly	2 times a week*
red wine (4.2%–6.0%)	wine in moderation	150 ml red wine (1 glass)
	1-2 s olives, nuts, seeds daily	
	herbs, spices, garlic, onions daily	
meat (2.6%–4.0%)	< 2 s red meat weekly	once a week beef or pork*
	<= 1 s processed meat weekly	
	2 s white meat weekly	once a week chicken*
milk and dairy products (1.3%–1.8%)	2 s dairy daily (pref. low fat)	300 ml milk or dairy products
		15 g cheese
eggs (0.8%–1.4%)	2-4 s weekly	3 eggs a week*
animal fats (1.0%–2.0%)		
	<= 2 s sweets weekly	200 kcal non-basic products
		**100 g animal products total*

Epidemiological evidence suggests that a traditional MD may be beneficial to health (Keys 1980). The term ‘Mediterranean Diet’ originated from the 1960s when studies suggested that people living in Crete and South Italy were having a lower incidence of coronary heart disease (Keys 1970). The Health Score of the MD is 122, which is higher than the recommended guidelines (Table 3), and the Sustainability Score for males (86) is below the guidelines. The question is: Is this healthy, cultural accepted Southern European diet transferrable to Northern European areas?

3.2. Defining the New Nordic Diet (NND)

We find an answer as we look into the Nordic Diet. Although the Mediterranean cuisine is also popular in Western European countries, food patterns differ significantly throughout different countries. We came across a Scandinavian variant of the Mediterranean diet, the NND. This Northern European diet consists of many local Scandinavian traditional products such as fish, berries, cabbage, rapeseed oil, rye, oats and game (Hahnemann 2010). Dietary components with substantial evidence of health-promoting properties that are part of the Nordic Nutritional Recommendations 2012 (Norden 2014) are naturally included in the NND; e.g. fruits, vegetables, potatoes, whole grains, nuts, fish and shellfish (Mithril et al. 2012). The diet is quantified in Table 2. The ‘New’ diet is also based on long local traditions; in the Middle Ages foods such as fresh herbs, legumes, cabbage and root vegetables played a major role in the Nordic Diet, but their use has decreased significantly over recent decades (Mithril et al. 2012).

Table 2. Quantification of the New Nordic Diet according to Uusitupa and Mithril.

Healthy Nordic Diet (Uusitupa et al. 2013)	**New Nordic Diet (Mithril et al. 2012)**
500 g/week wholegrain pasta and rice (25 en% whole grains)	
210 g bread/d (6 slices)	275 g wholegrain bread and cereals
>50% as rye, barley or oat	
150-200 g berries	75 g berries
175 g fruits	250 g fruits
175 g vegetables	150 g root vegetables
	30 g cabbages, 240 g other vegetables
	45 g legumes
	175 g potatoes
rapeseed or sunflower oil (2/3 unsaturated fats)	15 g rapeseed oil
soy oil based margarines	10 g butter
nuts and seeds unsalted	30 g nuts and seeds
	6 g wild plants, mushrooms, herbs
2 portions/d low-fat milk and cheese	450 g low-fat milk (+50 g other dairy)
	25 g cheese
3 portions fish/week (2 fatty)	43 g fish and shellfish (5g seaweed)
white meat, poultry, game	100 g meat (4 g game)
	25 g eggs (1/2)
50 g apple juice	
	75 g extras
	15 g sugar
	1000g coffee, tea, water (600g)

The NND can be described by overall guidelines: (a) more calories from plant foods and fewer from meat; b) more foods from the sea and lakes; and c) more foods from the wild countryside (Mithril et al. 2012). According to studies by Bere and Brug (2009, 2010), this diet has a positive health impact, and a low environmental impact, similar to the MD. Bere and Brug advise moderation of beverages such as coffee, soft drinks, fruit juice and alcohol, and fatty and sweet extras in between meals in order to increase the scores.

Our calculation results in a higher Health Score of 134 for the NND and results in the same Sustainability Score of 86 (see Table 3), compared to the MD. There is some research that confirms the health impact of the NND. Uusitupa et al. (2013) for instance investigated the effects of an isocaloric healthy Nordic diet on insulin sensitivity, lipid profile, blood pressure and inflammatory markers in people with metabolic syndrome. Uusitupa et al. concluded that a healthy NND improved lipid profile and had a beneficial effect on low-grade inflammation. In 2009, OPUS was launched as a comprehensive research project for optimal well-being, development and health of Danish children through a healthy NND. The preliminary results of the scientific research on the correlation between weight loss and the NND show that eating Nordic food is an effective way to curb obesity in the Danish population (Thorson et al. 2013).

Mithril et al. (2012) concluded that the principles and guidelines of the NND could be applied in any region. In the next section we will look if an application to the Low Lands is reasonable.

3.3. Defining the Low Lands Diet (LLD)

Although the Scandinavian culture stands closer to the Low Lands than the Mediterranean, it still differs significantly. The challenge is to define and investigate a LLD, with comparable qualities to the MD or NND. A similar health effect as the NND can be expected in the Low Lands with a traditionally, predominantly plant-based diet (semi-vegetarian), also with lots of fresh and regional vegetables, fruits and whole grains (bread, pancakes, porridge), a local vegetable oil, supplemented with limited amounts of fish, eggs, meat, and milk.

The Dutch diet from the beginning of the 20th century (1900-1940) is well described by Jobse-Van Putte and fit into this description. Research was done by interviewing older people from different areas and analyzing official documents. There are no quantitative diet surveys available prior to the 1960s. Other sources confirm the findings from Jobse-Van Putte (1995) (Knibbe 2001; Van Otterloo 1990). The following issues are typical for the LLD:

- People constrain themselves, especially to price of food. It should be cheap, fast and easy.
- There is an international, cosmopolitan mind-set, because the area is in between three cultural circles: Roman, Anglo-Saxon and German/Scandinavian. Culture, as well language, and foods are borrowed from different cultures.
- The Protestant-Calvinistic religion has resulted in an ethical relation towards food and abstinence, temperance, and pleasure, and an attitude towards food as a way to survive.
- The democratic, liberal and caring government is comparable to the Scandinavian countries, with comparable values towards food as a necessity, combined with a natural, balanced, and nutritious proposition.
- Due to an open trading economy, there is a lot of tolerance towards food habits of immigrants (Chinese, Indonesian, Jewish, Italian, Greek, Turkish and Moroccan) and an early adaption of coffee, tea, rice and spices (Albala 2003; Jobse-Van Putten 1995).

A general, typical LLD is described in Table 4. Some available statistics were used, on the consumption of bread, pulses, potatoes, milk, meat and fish between 1930 and 1950 (CBS 2001). Due to the low income situation, no food was wasted (Jobse-Van Putten 1995). This LLD is plant based and includes a maximum energy percentage (en%) of 30% deriving from an animal origin. In the countryside most of the people were self-sufficient. They had a vegetable garden and an acre with rye or other grains and a pig. Once a year the pig was slaughtered and the pork and grease was consumed until lent. Bread was baked once a week. Farmers in the lower grassland -clay and moor- areas (river sides, lake sides and coastal area) owned cows. One cow was available per four inhabitants. The butter was mostly sold and buttermilk was for own use. Porridge cars went by homes on a daily basis to sell porridge made of buttermilk and barley. People living in the eastern sand areas consumed a more rye based diet. In the cities more wheat was consumed. Typical for the culture is the cooking of hot meals in one pot (‘*stamppot’*) and for several days. Thanks to the trade connections, rice, spices, coffee and tea were common at an early stage. Fresh fish was only available in coastal zones; fresh water fish consumption was dropped in the 18th century, due to overfishing. Beef, poultry and game were not regular on the menu.

The Health Score of 106 and the Sustainability Score of 97 of the LLD (Table 3) are comparable to the recommended guidelines (Health Council 2006), but the Health Score is lower and the Sustainability Score higher than the MD and NND. The scores of the traditional LLD are higher than the present diet. Now we look for an interactive method to improve the suboptimal intake of vegetables, fruits, fiber and fish and to lower the salt consumption in the LLD.

Table 3. GHGE, LU, Sustainability Score, nutritional characteristics, and Health Score of the present Dutch, Mediterranean, New Nordic, historical Low Lands, and optimized Low Lands diets (males 31-50y).

		dietary guidelines	present Dutch	Mediterranean	New Nordic	historical Low Lands	optimized Low Lands
1	GHGE (kg CO_2-eq)	3.07	3.52	3.24	3.82	3.24	**2.60***
2	Land use (m^2*year)	3.08	4.15	4.15	3.42	3.18	**2.86**
	Sustainability score	101	82	86	86	97	**115**
1	Vegetables (grams)	200	119	300	**420**	179	215
2	Fruits (grams)	200	82	250	**350**	145	277
3	Fatty acids (en%)	25	34.5	**20.5**	21.5	25.2	24.2
4	Saturated fatty acids (en%)	10	12.7	6.9	**6.7**	8.4	7.3
5	Trans-fats (en%)	1	1.0	0.5	0.4	0.3	**0.2**
6	Free/added sugars (en%)	10	10.0	7.6	9.4	**3.5**	4.5
7	Dietary fiber (grams)	40	23	33	**47**	37	40
8	Salt (grams)	6.0	7.9	**5.0**	5.0	7.6	5.8
9	Fish (grams)	37	12	37	**43**	25	37
10	Energy in diet (kcal)	2500	2647	2503	2560	2651	**2500**
	Health score	100	71	122	**137**	106	123

best scores in **bold*

4. Methods: Linear programming

Although it cannot be assumed that a healthy diet will always have lower GHGE (Macdiarmid 2013), we do expect that linear programming will make it possible to find a diet with lower impacts than those diets found in literature. This is confirmed in a paper that is currently under submission (Van Dooren et al. 2014b). Several studies in other countries - for instance UK, France and New Zealand - have also successfully used linear programming for diet optimization.

Linear programming is a mathematical technique that allows the generation of optimal solutions (Dantzig G and M. 1997). The method we use for linear programming in this study is very similar to the one used by (Macdiarmid et al. 2012). This mathematical method optimizes an outcome which is a linear function of several variables that can be controlled (e.g. the amount of food eaten), while subject to a number of constraints (e.g. dietary requirements) (Macdiarmid et al. 2011). The linear programming algorithm minimizes the absolute changes in terms of portions to the present diet (see also Maillot et al. 2010); weighted by a proxy of popularity, while satisfying a number of constraints. Due to the weighing, it penalizes positive deviations from the present diet differently from negative deviations. More specifically the optimization weights are constructed from the normalized value of the total food consumption based on weight (n=206, based on (Van Rossum CTM et al. 2011)) for male adults (31-50y). In other words: Diets are improved by keeping as much as possible products from the starting point, and by adding products that are popular at the moment, in order to create a culturally acceptable diet.

The total GHGE of a diet consisting of amounts of n food products (x_1, x_2, ., x_n) and the associated GHGE of each food product per unit weight ($GHGE_i$) is as follows: Eq.3.

$$GHGE_{diet} = \sum_{i=1}^{n} x_i GHGE_i \qquad \textbf{Eq. 3}$$

In addition, the diet has to satisfy the energy and nutrient requirements (constraints) and, when applicable, an upper limit for total GHGE. Each constraint can be denoted as b_1, b_2, .., b_m, and with each food product i contributing a_{ij} per unit weight to requirement j, a set of j dietary constraints was established such that: Eq. 4.

$$b_j \geq \sum_{i=1}^{m} a_{ij} x_i \qquad \textbf{Eq. 4}$$

Optimization is done by linear programming using the newly developed Optimeal® software of Blonk Consultants and the Netherlands Nutrition Centre, which runs with MATLAB Compiler 7.16 and Microsoft Access Runtime. During optimization we use 33 nutrients and GHGE as constraints. Adequate intake levels and

dietary guidelines of 33 nutrients are given by the Netherlands Nutrition Centre (2008) and the Health Council of the Netherlands (Health Council 2001; 2006; 2009) as the first constraint. The 33 nutrients and nutritional indicators are: energy, protein, carbohydrates, total fat, saturated fatty acids, trans fatty acids, polyunsaturated fatty acids, cholesterol, dietary fiber, alcohol, water, sodium, calcium, phosphorus, magnesium, iron, copper, selenium, zinc, iodine, retinol, vitamin D, vitamins B1, B2, B6, B12, folic acid, vitamin C, n-3 fatty acids (EPA + DHA), fruit consumption and vegetable consumption. Secondly, the upper boundary for climate impact (GHGE) is set to 2.60 kg CO_2eq/day. This represents a 20% reduction of the present GHGE of the Dutch diet (males 3.52 kg CO_2eq/day (Marinussen et al. 2012)), as feasible target.

5. Results: an optimized LLD

Optimization of the historical LLD resulted in an increased content of vegetables, fruits and dietary fibers, and a decrease in salt. Table 4 shows the result of the historical research into the LLD and the results of optimization by linear programming. Due to the constraints and penalty rules, the optimization resulted in a diet which is palatable and in line with the traditional diet. Various elements of this diet are in use at the moment, for instance a high consumption of potatoes and wheat bread compared to other European countries, the preference for cabbage, root vegetables and local fruits (apple, pear), the level of milk consumption and the habits of drinking coffee, tea and beer.

Table 4: Quantification of the historical and optimized Low Lands Diet for male adults, by historical research and linear programming.

historical Low Lands diet	optimized Low Lands diet
350 g potatoes	350 g potatoes
180 g vegetables (leafy, roots, cabbages)	215 g vegetables (extra lettuce and kale)
145 g fruits (apple, pear, berries)	277 g fruits (extra pear)
18 g legumes	51 g legumes
	24 g nuts
35 ml soup	35 ml soup
210 g rye and wheat bread (6 slices)	210 g rye and wheat bread (6 slices)
30 g rice and 10 g other grain products	10 g other grain products
2 portions porridge incl. 250 ml buttermilk and 150 ml full fat milk	2 portions porridge incl. 325 ml skimmed milk and 150 ml full fat milk
20 g cheese	no cheese
40 g butter, rapeseed oil, margarine	40 g butter, rapeseed oil, margarine
25 g fish	37 g oily fish
55 g meat (pork, beef and chicken)	48 g meat (pork and chicken)
300 ml coffee, 250 ml tea	300 ml coffee, 250 ml tea
300 ml beer, 6 ml wine	300 ml beer
	300 ml water
32 g extras (sugar, jam, chocolate, syrup, cake)	32 g extras (sugar, jam, chocolate, syrup, cake)

Furthermore, this optimization placed the LLD scores in between the Health Scores of the MD and NND, but resulted in the highest Sustainability Score (i.e. lowest environmental impact, Table 3). GHGE is 2.60 kg CO_2-eq per day and LU 2.86 m^2*year. The sustainability scores (Table 3) of the Nordic, Mediterranean, traditional LLD and recommended dietary guideline are on the same level of about 100. Only the optimized LLD is higher. An unexpected result is that the Health Score of the optimized LLD is close to the high score of the NND. Both are higher than the MD, which is generally considered as very healthy.

The optimization results in a diet within the 33 nutritional constraints and with low GHGE and LU (or high Sustainability Score). To reach this diet, the consumption of (local and seasonal) fruits, vegetables and legumes

has to increase. Nuts should be added to the diet. The consumption of fish and white meat should be increased and the intake of cheese and beef has to be reduced. The optimized LLD seems to be a cultural acceptable option, which amply meets the nutritional and environmental constraints.

6. Discussion

In this paper we were able to define a nutritionally healthy, environmentally friendly, and culturally acceptable Low Lands Diet. The historical quantification of the diet before 1940 is subject to uncertainties. Changes in starting point will result in other optimal solutions. The qualities of the LLD are in line with the benefits of MD and LLD, based on the quality of historical diets from decades ago. In order to give relevant recommendations both historical, cultural patterns and present consumption have to be taken into account.

Both gastronomists and nutritionists are beginning to believe that there is a shared route to creating regional diets and an opportunity to develop a healthy diet that bridges gastronomy, health and sustainability (Mithril et al. 2012). Eating according to the Dutch dietary guidelines is one way to get to a healthier and a lower environmental impact than the present Dutch diet (Health Council 2011). However, further improvements in health scores, GHGE, and LU are within reach, we concluded in (Van Dooren et al. 2014a). We demonstrated that the MD is generally the health focus option with a high Sustainability Score. On the other hand, this paper demonstrates that the NND is also a prototype regional diet taking health, food culture, palatability and the environment into account. The principles and guidelines can indeed be applied in any region (Mithril et al. 2012). We demonstrated the possibility to apply this to the Low Lands.

This study confirms that if we combine the strong points of historical diets, with optimization on health and sustainability parameters, then even a local diet with higher scores is possible. Although the NND has the highest Health Score, a higher Sustainability Score is found in the optimized LLD.

Earlier, Swedish (Livsmedelsverket 2009) and Finnish governments (Steering Group 2010) have put together committees to give policy advice on environmentally effective diets. In line with these recommendations, four simple considerations for environmental impact were used in the formulation of the NND:

- Focus on locally grown foods.
- Focus on foods from organic food production.
- Focus on composing a proportion of the diet from foods sourced from the wild countryside, encouraging biodiversity and minimizing use of fertilizers and pesticides.
- Focus on minimizing waste and utilizing all of every food purchased (Mithril et al. 2012).

Saxe et al. (2013) confirmed that the climate impact of the local, organic NND is lower than the average and recommended diets. The four considerations mentioned above are also transferrable to and in use in the Low Lands, although the size of wild countryside in the Low Lands is much smaller, even a century ago. These Scandinavian recommendations and guidelines have a qualitative character. In this study we have quantified the sustainability in a combined score of GHG and LU. We also demonstrate that the NND is not optimal in the Sustainability Score. The reason is a relative high amount of meat, fish, vegetables and fruits. The optimized LLD showed that with smaller quantities of these products comparable nutritional health can be achieved. It is important to mention the common ground of the results for MD, NND and LLD. All diets consist of basic food products, which are high in nutrient density and most of the time low in energy density. Most of the volume is plant based products, such as whole grains, fruits, vegetables, oils, pulses and nuts. All include animal products in moderate quantities.

When interpreting the results it is important to consider that the methodology used to score health and sustainability is based on a limited number of parameters. Other parameters, such as fossil energy use, water use, and ReCiPe-score were outside the scope of this study. The data are not based on dietary assessments, but on a general description from the literature about different diets. This results in some uncertainties. Sustainability scores are based on Dutch data on LCAs of common food products. Most of these products are familiar to the Mediterranean and Nordic cuisine, but difference in transport and agricultural methods would result in slightly different calculations of GHGE and LU. On the other hand, the results reflect a hypothetical situation where these NND and MD are transferred to the Low Lands. Because of the limited number of products (206) used in the calculations, no detailed results of the diets could be given. For instance some traditional products were missing and replaced by comparable products (e.g. oats and barley by wheat). Furthermore, the study should not be interpreted as a retrospective study on the sustainability impact of the situation before 1940. Surely, energy

intensity, processing and yields differ significantly over time. The calculation of the traditional LLD reflects the situation if male adults from our area were to eat as our ancestors and grandparents did 80 years ago. Rather than trying out diets recommended in the literature, this study confirms the usefulness of linear programming to improve existing or culturally relevant diets.

7. Conclusion

An optimized Low Lands Diet has the same nutritional characteristics as the Mediterranean and the Nordic Diet, and results in a lower environmental impact and a higher sustainability score. These results are relevant because an adaptation of the historical diet, which fits better into the present eating habits, climate and agricultural tradition of the Low Lands, is assumed to be easier to achieve than a transition into a foreign Southern or Northern European diet.

8. References

Albala K (2003) Food in Early Modern Europe, 1500-1800. Greenwood Press, Westport, CT

Bach-Faig A et al. (2011) Mediterranean diet pyramid today. Science and cultural updates. Public Health Nutrition 14:2274-2284

Bere E, Brug J (2009) Towards health-promoting and environmentally friendly regional diets? a Nordic example. Public Health Nutrition 12:91-96

Bere E, Brug J (2010) Is the term 'Mediterranean diet' a misnomer? Public Health Nutrition 13:2127-2129

Blonk H, Ponsioen T, Kool A, Marinussen M (2011) The Agri-foorprint method; Methodological LCA framework, assumptions and applied data, Version 1.0 edn. Blonk Milieu Advies, Gouda

BSI (2008) PAS 2050:2008 Specification for the assessment of the life cycle greenhouse gas emissions of goods and services. British Standards, Carbon Trust, Defra, London, UK

Buchner B et al. (2010) Double Pyramid: healthy food for people, sustainable food for the planet. Barilla Center for Food & Nutrition, Milan, Italy

CBS (2001) Two hundred years of statistics in timelines 1800-1999 (In Dutch: Tweehonderd jaarstatistiek in tijdreeksen 1800–1999). RuG, CBS, Amsterdam, Netherlands

CBS (2012) More people overweight. Web magazine, 04 July 2012, accessed 2014-04-16: http://www.cbs.nl/en-GB/menu/themas/gezondheid-welzijn/publicaties/artikelen/archief/2012/2012-3651-wm.htm

Dantzig G, M. T (1997) Linear programming 1: introduction. Springer-Verlag, New York

Dutilh C, Kramer KJ (2000) Energy consumption in the food chain. Ambio 29:98-101

FAO Biodiversity and sustainable diets united against hunger. In: International Scientific Symposium, Rome, 3-5 november 2010. FAO Headquarters, Rome, Italy

Fidanza F, Alberti A (2005) The Healthy Italian Mediterranean Diet Temple Food Guide. Nutrition Today 40:71-78

Hahnemann T (2010) Eat your way to health and happiness with the Nordic diet. Quadrille Publishing Limited, London, UK

Health Council (2001) Nutritional standards for energy, protein, fat and carbohydrates (In Dutch: Voedingsnormen energie, eiwitten, vetten en verteerbare koolhydraten). Gezondheidsraad, The Hague, Netherlands

Health Council (2009) Towards an adequate intake of vitamins and minerals (In Durch: Naar een voldoende inname van vitamines en mineralen). Gezondheidsraad, The Hague, Netherlands

Health Council (2006) Guidelines for Good Nutrition 2006 (In Dutch: Richtlijnen Goede Voeding 2006). Gezondheidsraad, The Hague, Netherlands

Health Council (2011) Guidelines for a healthy diet: the ecological perspective. Gezondheidsraad, The Hague, NL

Jobse-Van Putten J (1995) Simple but nutritious (in Dutch; Eenvoudig maar voedzaam. Cultuurgeschiedenis van de dagelijkse maaltijd in Nederland). 1 edn. Uitgeverij Sun BV, Nijmegen, Netherlands

JRC (2010) ILCD Handbook: General guide for Life Cycle Assessment - Detailed guidance European Commission, Joint Research Centre, Institute for Environment and Sustainability Ispra, Italy

Kennedy ET, Ohls J, Carlson S, Fleming K (1995) The Healthy Eating Index: Design and Applications. Journal of the American Dietetic Association 95:1103-1108

Keys A (1970) Coronary heart disease in seven countries. Circulation Suppl to vol 41:1-211

Keys A (1980) Seven Countries: A Multivariate Analysis of Death and Coronary Heart Disease. Annals of Internal Medicine 93:786-787

Knibbe MT (2001) The development of the nutritional situation in The Netherlands 1851-1950 (In Dutch: De ontwikkeling van de voedselsituatie in Nederland, 1851-1950). NEHA yearbook 64:200-226

Livsmedelsverket (2009) The National Food Administration's environmentally effective food choices. Livsmedelverket, National Food Administration Sweden, Stockholm, Sweden

Macdiarmid JI, Kyle J, Horgan G, Loe J, Fyfe C, Johnstone A, McNeill G (2011) Livewell: a balance of healthy and sustainable food choices. WWF, Rowett Institute of Nutrition and Health Aberdeen, UK

Macdiarmid JI (2013) Is a healthy diet an environmentally sustainable diet? Proceedings of the Nutrition Society 72:13-20

Macdiarmid JI, Kyle J, Horgan GW, Loe J, Fyfe C, Johnstone A, McNeill G (2012) Sustainable diets for the future: can we contribute to reducing greenhouse gas emissions by eating a healthy diet? The American Journal of Clinical Nutrition 96:632-639

Maillot M, Vieux F, Amiot MJp, Darmon N (2010) Individual diet modeling translates nutrient recommendations into realistic and individual-specific food choices. The American Journal of Clinical Nutrition 91:421-430

Marinussen M, Kramer G, Pluimers J, Blonk H (2012) The environmental impact of our food an analysis based on the food consumption survey 2007-2010 (in Dutch). Blonk Consultants, Gouda, Netherlands

Mithril C, Dragsted LO, Meyer C, Tetens I, Biltoft-Jensen A, Astrup A (2013) Dietary composition and nutrient content of the New Nordic Diet. Public Health Nutr 16:777-785

Mithril C, Dragsteda LO, Meyera C, Blauerta E, Holta MK, Astrupa A (2012) Guidelines for the New Nordic Diet. Public Health Nutrition FirstView:1-7

Netherlands Nutrition Centre (2008) Dutch Food Tables 2008 (Nederlandse Voedingsmiddelentabel 2008) vol nr 200. Voedingscentrum, The Hague, Netherlands

Norden (2014) Nordic Nutrition Recommendations 2012; Integrating nutrition and physical activity. Nordic Council of Ministers, Copenhagen, Denmark

Pereira HM et al. (2010) Scenarios for Global Biodiversity in the 21st Century. Science 10:1503-1509

Rockström J et al. (2009) A safe operating space for humanity. Nature 461:472-475

Saxe H, Larsen TM, Mogensen L (2013) The global warming potential of two healthy Nordic diets compared with the average Danish diet. Climate Change 116:249-262

Sevenster MN, Blonk H, Flier Svd (2010) Milieuanalyses Voedsel en Voedselverliezen Ten behoeve van prioritaire stromen ketengericht afvalbeleid. CE Delft/ Blonk Milieu Advies, Delft, Netherlands

Steering Group (2010) Food for Tomorow, Proposal for Finland's National Food Strategy. Minister of Agriculture and Forestry, Helsinki, Finland

Stehfest E, Bouwman L, van Vuuren D, den Elzen M, Eickhout B, Kabat P (2009) Climate benefits of changing diet. Climatic Change 95:83-102

Trichopoulou A et al. (2005) Modified Mediterranean diet and survival: EPIC-elderly prospective cohort study. BMJ 330:991-997

Uusitupa M et al. (2013) Effects of an isocaloric healthy Nordic diet on insulin sensitivity, lipid profile and inflammation markers in metabolic syndrome - a randomized study (SYSDIET). J Intern Med 274:52-66

Van Dooren C, Marinussen M, Blonk H, Aiking H, Vellinga P (2014a) Exploring dietary guidelines based on ecological and nutritional values: A comparison of six dietary patterns. Food Policy 44:36-46

Van Dooren C, Tyszler M, Kramer G, Aiking H, Vellinga P (2014b) Combining low price, low climate impact and high nutritional value in one basket: example of diet optimisation by linear programming. Proceedings of the Nutrition Society ***submitted***

Van Kreijl CF, Knaap AGAC, van Raaij JMA (2006) Our food, our health: Healthy diet and safe food in the Netherlands. National Institute for Public health and the Environment, Bilthoven, the Netherlands

Van Otterloo AH (1990) Eating and appetite in the Netherlands [1840-1990], a historical-sociological study. (In Dutch: Eten en eetlust in Nederland [1840-1990], een historisch-sociologische studie). vol 1 ed. Uitgeverij Bert Bakker, Amsterdam, Netherlands

Van Rossum CTM, Fransen HP, Verkaik-Kloosterman J, Buurma-Rethans EJM, MC O (2011) Dutch National Food Consumption Survey 2007-2010: Diet of children and adults aged 7 to 69 years. RIVM, Bilthoven

Vringer K, Benders R, Wilting 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 69:2510-2516

Willett W, Sacks F, Trichopoulou A, Drescher G, Ferro-Luzzi A, Helsing E, Trichopoulos D (1995) Mediterranean diet pyramid: a cultural model for healthy eating. Am J Clin Nutr 61:1402S-1406

Willett WC (2001) Eat, Drink, and Be Healthy: The Harvard Medical School Guide to Healthy Eating. Hardard University Harvard, USA

WHO (2003) Diet, nutrition and the prevention of chronic diseases, WHO technical report series. WHO, Geneva, Switserland

WWF (2012) Living Planet Report 2012. WWF, Gland, Switserland

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