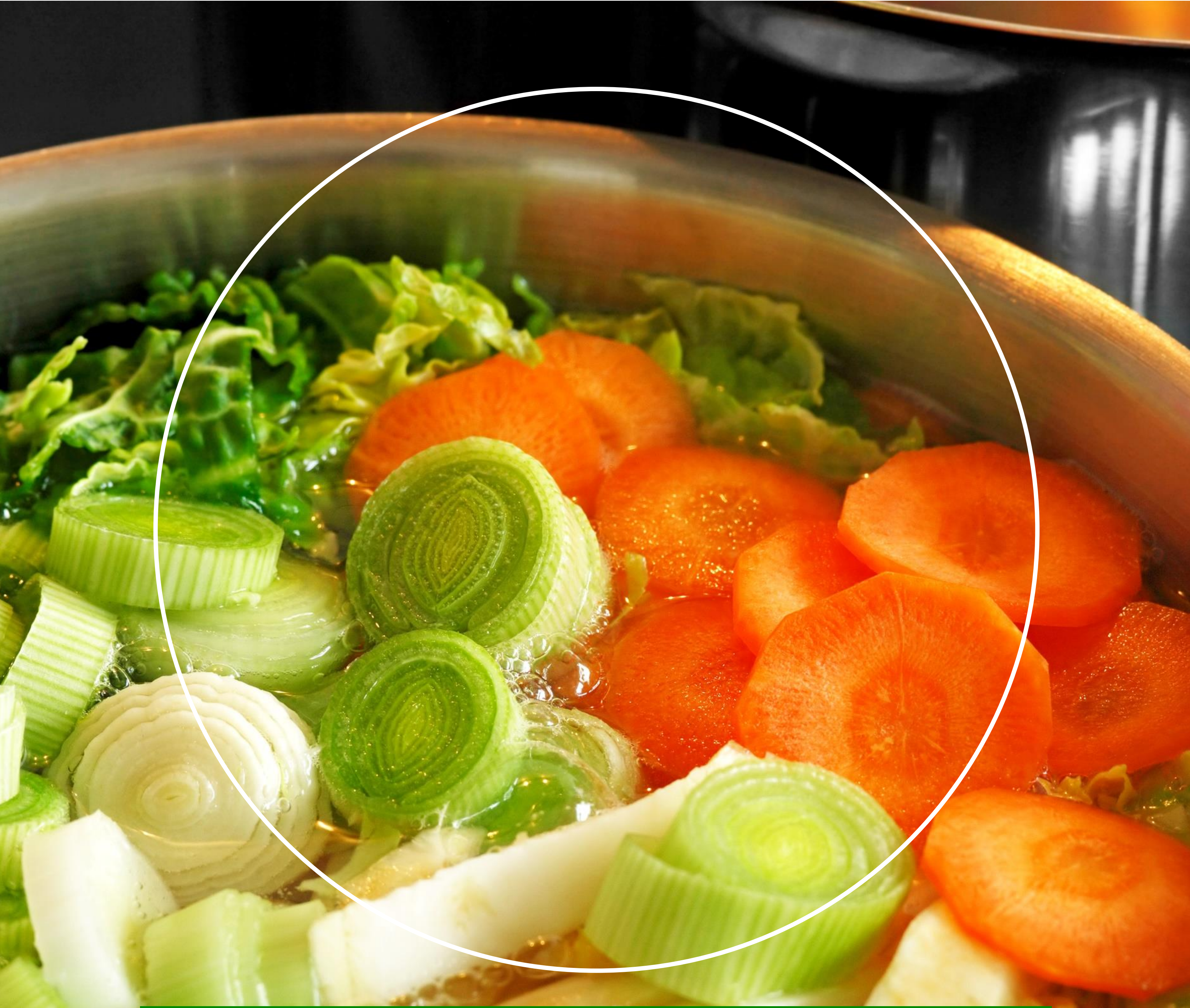

Change in Diet-related Environmental Impact by Substituting Meat and Dairy for Alternatives

Dutch National Food Consumption Survey 2019-2021

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Synopsis

This research analyzed the environmental impact of food consumption in the Netherlands, using data from the newest Dutch National Food Consumption Survey 2019-2021. In this population sample of 1747 Dutch adults, the average meat and dairy consumption was 108.0 and 346.2 grams/day, respectively. The environmental impact of daily diets was compared across days with and without meat and dairy consumption. On days when individuals consumed both meat and dairy, their diets had higher greenhouse gas emissions compared with days when they did not consume meat and dairy: 5.3 kg CO2-eq/day for meat and dairy days and 3.0 kg CO2-eq/day for days without meat and dairy. Likewise, their daily diets with meat and dairy consumption showed higher levels of land use (3.1 m^2·year/day), terrestrial acidification (51.8 kg SO2-eq·10^{-3}/day), marine eutrophication (8.6 kg Neq·10^{-3}/day), and freshwater eutrophication (37.6 kg Peq·10^{-5}/day), compared with their daily diets without meat and dairy consumption, which measured 2.2 m^2·year/day, 15.0 kg SO2-eq·10^{-3}/day, 3.4 kg Neq·10^{-3}/day, and 28.2 kg Peq·10^{-5}/day, respectively. Nevertheless, on days with meat and dairy consumption, their diets showed less blue water use compared with days without meat and dairy consumption: 174.2 L/day for meat and dairy days and 234.2 L/day for days without meat and dairy.

If individuals were to replace meat and dairy by plant-based meat and dairy replacers (such as vegan meat analogues, legumes, soy milk, and nuts/seeds) in their daily diets, it could potentially lead to a reduction in greenhouse gas emissions of 2.1 (38.5%) kg CO2-eq/day, land use of 0.6 (18.2%) m^2·year/day, terrestrial acidification of 33.3 (61.6%) kg SO2-eq·10^{-3}/day, as well as freshwater eutrophication of 6.4 (15.3%) kg Peq·10^{-5}/day and marine eutrophication of 4.5 (47.0%) kg Neq·10^{-3}/day. Therefore, lowering meat and dairy consumption in the Netherlands has the potential to substantially reduce the environmental impact of food consumption, with the exception of blue water use. By making smart choices for plant-based foods with lower blue water use, this indicator could be improved.

Background

The way we currently produce and consume food has a significant environmental impact, jeopardizing the stability of planetary ecosystems. Globally, food production and consumption account for up to 30% of total greenhouse gas emissions, 40% of global land use, and 70% of freshwater use. Inappropriate use of nitrogen and phosphorus leads to eutrophication in lakes and coastal zones (Willett, 2019). Meat and dairy stand out as the primary contributors to this environmental impact (Biesbroek, 2014). Moving towards a diet with less meat and dairy but more plant-based foods may substantially reduce the environmental impact and enhance planetary health.

A previous research compared the greenhouse gas emissions and blue water use of daily diets in Dutch adults on days with or without meat and dairy consumption, using data from the Dutch National Food Consumption Survey 2012-2016 (Heerschop, 2022). Recently, the newest Dutch National Food Consumption Survey 2019-2021 became available, providing the most up-to-date situation of food consumption in the Netherlands. Based on this latest data, this research provided an updated assessment of the environmental impact of daily diets of Dutch adults and expanded the analysis to include land use, terrestrial acidification, freshwater eutrophication, and marine eutrophication – four additional environmental impact indicators. Additionally, this research estimated the potential reduction in environmental impact if individuals replaced meat and dairy by meat and dairy replacers in their diets.

Research Results and Interpretation

Consumption Levels of Meat, Dairy, Meat Replacers, and Dairy Replacers

In this population sample of Dutch adults (18-79 years), a total of 1747 participants recorded detailed information on food consumption on a total of 3494 days. Of all consumption days, the average total meat consumption was 108.0 grams/day, with breakdowns for red meat of 28.6 grams/day, processed meat of 45.4 grams/day, white meat of 16.7 grams/day, and seafood of 17.3 grams/day (**Figure 1a**). The average total dairy consumption was 346.2 grams/day, comprising milk and milk beverages at 172.0 grams/day, yogurt at 81.6 grams/day, cheese at 54.3 grams/day, cream desserts and pudding at 24.5 grams/day, ice cream at 7.0 grams/day, and cream and creamer at 6.8 grams/day (**Figure 1b**). The average total meat replacers consumption was 43.0 grams/day, which consists of meat analogues of 5.0 grams/day, legumes of 7.2 grams/day, eggs of 16.6 grams/day, and nuts and seeds of 14.3 grams/day (**Figure 1c**). The average total dairy replacers consumption was 14.5 grams/day, with breakdowns for plant-based dairy (such as soy milk, almond milk, rice milk, and soy yogurt) of 11.6 grams/day, coconut milk of 1.1 grams/day, and sorbet of 1.8 grams/day (**Figure 1d**).

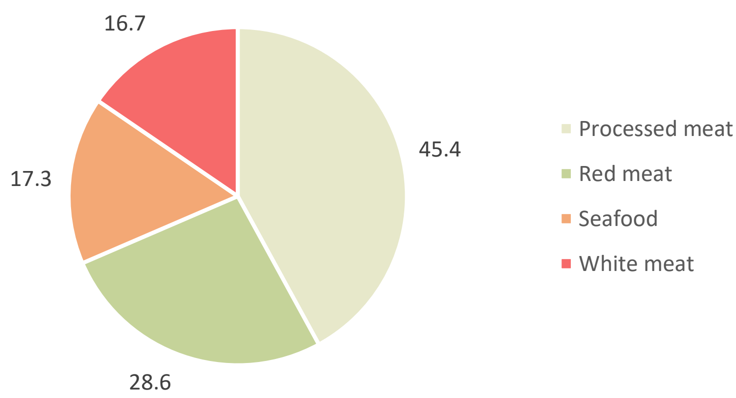
Of the total 3494 days of dietary assessments, 432 (12.4%) days were meat-free; 199 (5.7%) days were dairy-free; and 45 (1.3%) days had neither meat nor dairy consumption, while there were 2908 (83.2%) days with both meat and dairy consumption (**Table 1**).

Table 1 – Numbers of days of meat and dairy consumption of the study population

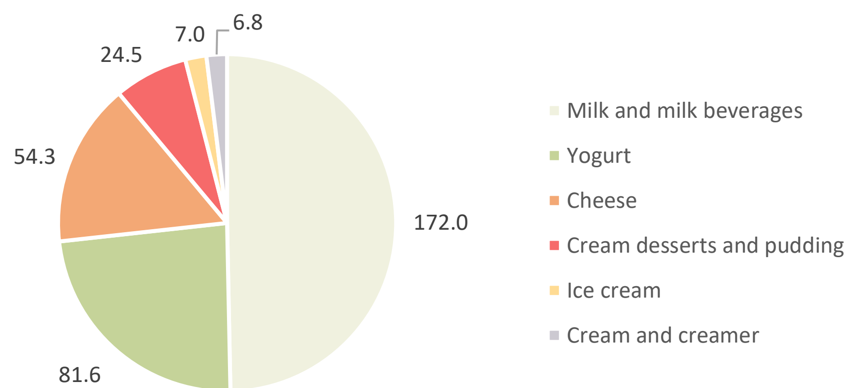
	Days consumed dairy	Days without dairy	Total
Days consumed meat	2908 (83.2%)	154 (4.4%)	3062 (87.6%)
Days without meat	387 (11.1%)	45 (1.3%)	432 (12.4%)
Total	3295 (94.3%)	199 (5.7%)	3494 (100%)

Figure 1 – Average consumption of meat (a), dairy (b), meat replacers (c), and dairy replacers (d) in grams per day of the study population

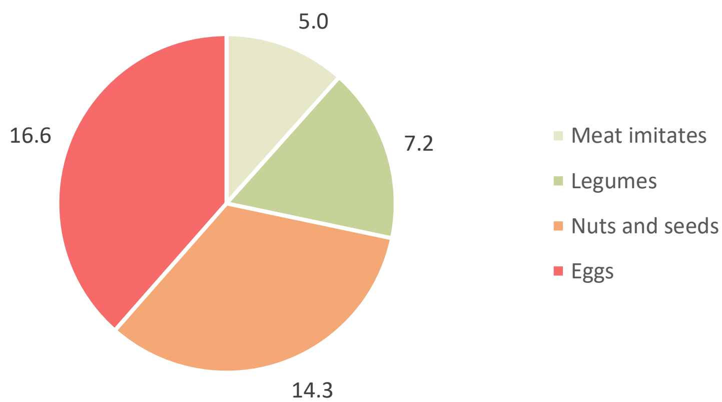
(a) Meat consumption



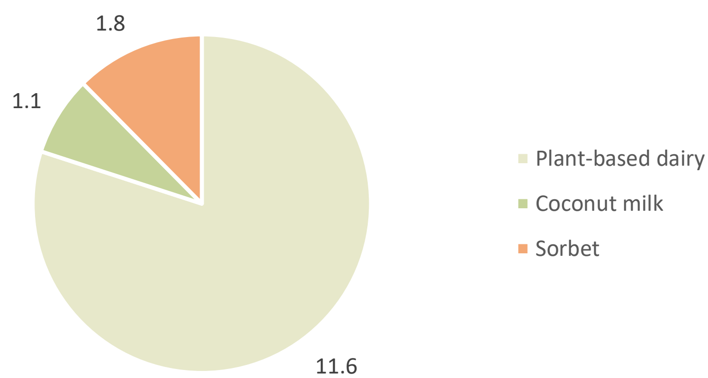
(b) Dairy consumption



(c) Meat replacers consumption



(d) Dairy replacers consumption[a]



[a] Plant-based dairy includes soy milk, rice milk, almond milk, oat milk, soy yogurt, and other plant-based dairy products.

Environmental Impact of Daily Diets

Table 2 shows the dietary environmental impact of Dutch adults on any given day, separated by days with and without meat and dairy consumption. The environmental impact of days with both meat and dairy consumption was the highest, followed by days with meat but no dairy consumption, days with dairy but no meat consumption, and days without meat and dairy consumption, with the exception of blue water use.

On days with meat and dairy consumption, greenhouse gas emissions were 5.3 kg CO2-eq/day, contrasting to 3.0 kg CO2-eq/day on days without meat and dairy consumption. Days with meat and dairy consumption showed higher levels of land use (3.1 m^2·year/day), terrestrial acidification (51.8 kg SO2-eq·10^{-3}/day), freshwater eutrophication (37.6 kg Peq·10^{-5}/day), as well as marine eutrophication (8.6 kg Neq·10^{-3}/day), compared with days without meat and dairy consumption, which measured 2.2 m^2·year/day, 15.0 kg SO2-eq·10^{-3}/day, 28.2 kg Peq·10^{-5}/day, and 3.4 kg Neq·10^{-3}/day, respectively. Nevertheless, the level of blue water use was the highest on days without meat and dairy consumption (234.2 L/day), compared with days with meat and dairy consumption (174.2 L/day) and days with meat but no dairy consumption (149.6 L/day). The explanations of higher blue water use on days without meat and dairy are discussed in detail in **Methods and Explanation**.

Given the difference in energy intake on days with and without meat and dairy consumption, the observed environmental impact of daily diets for each individual was scaled to diets with a 2000 kcal/day energy intake. This procedure enhances the comparability of the environmental impact among consumption days, as consuming larger quantities of food and calories may result in higher environmental impact, irrespective of the types of food consumed. However, it is possible that individuals may intentionally consume less calories from specific foods on certain days because of food preferences or health reasons. Moreover, it should be noted that potential underreporting of food consumption and energy intake in the survey data is partly mitigated by scaling the environmental impact indicators to diets of 2000 kcal/day energy intake.

For all indicators, the environmental impact of 2000 kcal/day-scaled diets was higher than the observed values, and the difference between days with and without meat and dairy consumption became smaller. This is because the majority of individuals reported an energy intake of less than 2000 kcal/day, and on days without meat and dairy consumption, the energy intake was the lowest. By scaling their observed diets to 2000 kcal/day, the environmental impact of the diets naturally increased. Nevertheless, the patterns of the difference in environmental impact across consumption days remained consistent.

In addition to energy intake, age, gender, education level, and migration background may also influence the environmental impact of diets. Therefore, it is important to gain deeper insights into the extent to which meat and dairy consumption contributed to the dietary environmental impact, irrespective of these factors. To calculate this, regression models were applied. Results from the regression models showed that, of all consumption days, meat and dairy consumption was estimated to account for 1.7 kg CO2-eq/day of greenhouse gas emissions, 0.6 m^2·year/day of land use, 25.8 kg SO2-eq·10^{-3}/day of terrestrial acidification, 6.2 kg Peq·10^{-5}/day of freshwater eutrophication, and 3.4 kg Neq·10^{-3}/day of marine eutrophication. However, meat and dairy consumption was estimated to result in 31.2 L/day less of blue water use, in reference to days without meat and dairy consumption. Further details of this regression analysis can be found in section **Methods and Explanation** and **Figure 2**.

Table 2 – Environmental impact and energy intake of diets on days with and without meat and dairy consumption[a]

	Total	Meat and dairy	Meat but no dairy	Dairy but no meat	No meat and no dairy
Energy intake, kcal	1992 (677)	2026 (669)	1778 (760)	1856 (645)	1715 (792)
Greenhouse gas emissions, kg CO2-eq/day					
Observed	5.0 (2.1)	5.3 (2.1)	4.3 (2.0)	3.6 (1.3)	3.0 (1.4)
Per 2000 kcal	5.2 (1.8)	5.4 (1.8)	5.1 (1.8)	4.1 (1.3)	3.9 (1.9)
Land use, m^2·year/day					
Observed	3.0 (1.2)	3.1 (1.2)	2.8 (1.2)	2.3 (0.8)	2.2 (1.0)
Per 2000 kcal	3.1 (1.0)	3.2 (1.0)	3.2 (1.1)	2.5 (0.7)	3.0 (1.9)
Blue water use, L/day					
Observed	176.8 (130.7)	174.2 (128.3)	149.6 (89.1)	200.3 (152.9)	234.2 (156.6)
Per 2000 kcal	189.0 (150.0)	182.3 (145.8)	185.6 (114.1)	228.3 (174.7)	295.3 (205.1)
Terrestrial acidification, kg SO2-eq·10^{-3}/day					
Observed	48.2 (28.4)	51.8 (28.6)	39.0 (28.5)	29.2 (12.7)	15.0 (6.9)
Per 2000 kcal	50.2 (27.7)	53.2 (28.0)	45.9 (30.6)	32.7 (13.1)	22.1 (17.9)
Freshwater eutrophication, kg Peq·10^{-5}/day					
Observed	36.4 (15.0)	37.6 (15.0)	35.5 (16.9)	28.0 (11.1)	28.2 (13.4)
Per 2000 kcal	37.6 (13.0)	38.3 (13.0)	41.0 (13.6)	31.1 (10.1)	36.3 (15.6)
Marine eutrophication, kg Neq·10^{-3}/day					
Observed	8.1 (4.7)	8.6 (4.7)	6.7 (4.8)	5.2 (2.0)	3.4 (1.5)
Per 2000 kcal	8.4 (4.6)	8.9 (4.6)	7.8 (5.1)	5.9 (2.0)	4.8 (3.4)

[a] Data are presented as mean (standard deviation).

Reduction in Environmental Impact: Substituting Meat with Meat Replacers and Dairy with Dairy Replacers

Replacing meat by meat replacers and dairy by dairy replacers may alleviate the dietary environmental impact. Substitution analyses were performed to calculate the potential reduction in greenhouse gas emissions, land use, terrestrial acidification, freshwater eutrophication, and marine eutrophication if individuals replaced meat by meat replacers and dairy by dairy replacers in their daily diets. Meat replacers include vegetarian or vegan meat analogues, eggs, legumes, and nuts/seeds; plant-based meat replacers include vegan meat analogues, legumes, and nuts/seeds. The difference between vegetarian meat analogues and vegan meat analogues is that vegetarian meat analogues may still contain dairy products, such as cheese burgers, while plant-based meat analogues do not contain any animal-based products. Dairy replacers are plant-based products such as soy milk, rice milk, soy yogurt, vegan cheese, and sorbet. Reduction in blue water use was not calculated because in the present survey days with meat and dairy consumption showed less blue water use (60.0 L/day), compared to days without meat and dairy consumption (**Table 2**). A previous report, based on data from the Dutch National Food Consumption Survey 2012-2016, has shown that replacing meat and dairy by plant-based meat and dairy replacers may lead to a reduction of 27.6 L/day of blue water (Heerschop, 2022).

Table 3 shows the estimated average reduction per person in environmental impact that would be achieved if individuals replaced meat by meat replacers and dairy by dairy replacers in their daily diets. If individuals replaced both meat and dairy by plant-based meat replacers and dairy replacers, greenhouse gas emissions would decrease by 2.1 kg CO2-eq/day (14.6 kg CO2-eq/week) by 38.5%. The reduction in land use would be 0.6 $m^2 \cdot$year/day (4.4 $m^2 \cdot$year/week), representing a 18.2% decrease. For terrestrial acidification, the reduction would be 33.3 kg SO2-eq$\cdot 10^{-3}$/day (233.1 kg SO2-eq$\cdot 10^{-3}$/week) by 61.6%. The reduction in freshwater eutrophication would be 6.4 kg Peq$\cdot 10^{-5}$/day (44.7 kg Peq$\cdot 10^{-5}$/week) by 15.3%. Marine eutrophication would decrease by 4.5 kg Neq$\cdot 10^{-3}$/day (31.6 kg Neq$\cdot 10^{-3}$/week) by 47.0%. Replacing meat by meat replacers alone or replacing dairy by dairy replacers alone would also reduce the dietary environmental impact, yet to a smaller degree (**Table 3**).

Table 3 – Estimated reduction in environmental impact if individuals replaced meat and dairy by meat and dairy replacers in their daily diets[a]

	Meat by meat replacers	Dairy by dairy replacers	Meat by plant-based meat replacers and dairy by dairy replacers
Greenhouse gas emissions, kg CO_2-eq			
With 1 day change	1.2 (1.3)	0.9 (0.7)	2.1 (1.5)
With 1 week change	8.1 (9.4)	6.5 (4.6)	14.6 (10.4)
Percentage reduction, %	19.6 (16.1)	19.1 (12.0)	38.5 (15.2)
Land use, m^2·year			
With 1 day change	0.5 (0.6)	0.2 (0.3)	0.6 (0.7)
With 1 week change	3.2 (4.5)	1.7 (1.9)	4.4 (4.7)
Percentage reduction, %	11.9 (17.2)	8.4 (7.9)	18.2 (17.6)
Terrestrial acidification, kg SO_2-eq·10^{-3}/day			
With 1 day change	18.1 (25.1)	13.5 (9.6)	33.3 (27.7)
With 1 week change	127.0 (175.7)	94.3 (67.2)	233.1 (194.0)
Percentage reduction, %	27.2 (24.9)	30.6 (19.0)	61.6 (19.0)
Freshwater eutrophication, kg Peq·10^{-5}/day			
With 1 day change	4.6 (8.1)	2.4 (3.7)	6.4 (8.6)
With 1 week change	32.4 (56.5)	16.5 (26.0)	44.7 (60.5)
Percentage reduction, %	10.3 (12.7)	6.6 (7.2)	15.3 (13.3)
Marine eutrophication, kg Neq·10^{-3}/day			
With 1 day change	2.7 (4.1)	1.9 (1.3)	4.5 (4.4)
With 1 week change	18.9 (29.0)	13.0 (9.3)	31.6 (30.5)
Percentage reduction, %	22.6 (24.7)	25.0 (16.1)	47.0 (21.2)

[a] Data are presented as mean (standard deviation).

Methods and Explanation

Study Population

Information on daily food and nutrition consumption was obtained from the Dutch National Food Consumption Survey 2019-2021, conducted by the National Institute for Public Health and the Environment (RIVM). For this research, data from 1747 Dutch adults were used, with in total 3494 days of dietary assessments. The survey sampling aimed to create a representative population sample in the Netherlands concerning age, education level, region of residence, and diet across a calendar year (season and days of the week). Demographic characteristics of the study population are presented in **Table 4**. Compared with the previous study using the Dutch National Food Consumption Survey 2012-2016 (Heerschop, 2022), food consumption patterns may naturally change and therefore results can be different from the previous study.

Dietary consumption was assessed with two 24h dietary recalls on two non-consecutive days with an interval of approximately 4 weeks. Standardized interviews were conducted by trained interviewers using the GloboDiet software (IARC, Lyon, France). All food items were classified according to the GloboDiet food list and were further linked to the Dutch Food Composition Database. A more detailed description of the Dutch National Food Consumption Survey can be found elsewhere (van Rossum, 2023).

Table 4 – Demographic characteristics of the study population[a]

Participants, n	1747
Female, n (%)	867 (49.6)
Days of dietary assessments, n	3494
Age, years	55.0 (15.5)
Weight, kg	81.4 (16.7)
Height, cm	174.7 (9.6)
BMI, kg/m^2	26.6 (5.1)
Education level, n (%)	
Low	445 (25.5%)
Middle	633 (36.2%)
High	669 (38.3%)
Migration background, n (%)	
Dutch, non-immigrants	1509 (86.4%)
Western immigrants	114 (6.5%)
Non-western immigrants	110 (6.3%)
Unspecified, others	14 (0.8%)

[a] Data are presented as mean (standard deviation) if not specified.

Environmental Impact Indicators

The dietary environmental impact was calculated with the Life Cycle Analysis. This method calculates the environmental impact of a food by compiling an inventory of all relevant materials and emission flows throughout the entire life cycle of this food product, spanning from primary production to consumption. The Life Cycle Analysis applied an attributional approach with a hierarchical perspective following the ISO 14040 and 14044 guidelines. Economic allocation was applied when production processes led to more than one food product, with the exception of milk, for which bio-physical allocation was used. The primary database includes approximately 250 foods and drinks, which covers 75% of the food consumption in the Netherlands. For foods and drinks lacking primary data, their environmental impact was extrapolated from similar food products. These food products were matched to their analogues based on expert judgement and the similarities in food types, production systems, and ingredient composition. For composite dishes, standardized recipes from the Dutch Food Composition Database were used. Animal feed is considered in calculating the blue water use of animal foods. However, animal feed often relies on rain water (green water) and this is not included in the current data. Compared with the previous report (Heerschop, 2022), this research used the updated data of environmental impact of foods. This new updated data improves the estimation of the environmental impact of a food product. Blonk Sustainability (Gouda, The Netherlands) carried out the Life Cycle Analysis inventories on behalf of the National Institute for Public Health and the Environment (RIVM). More detailed information on this Life Cycle Analysis and the database used is described elsewhere (Vellinga, 2019; Vellinga, 2023).

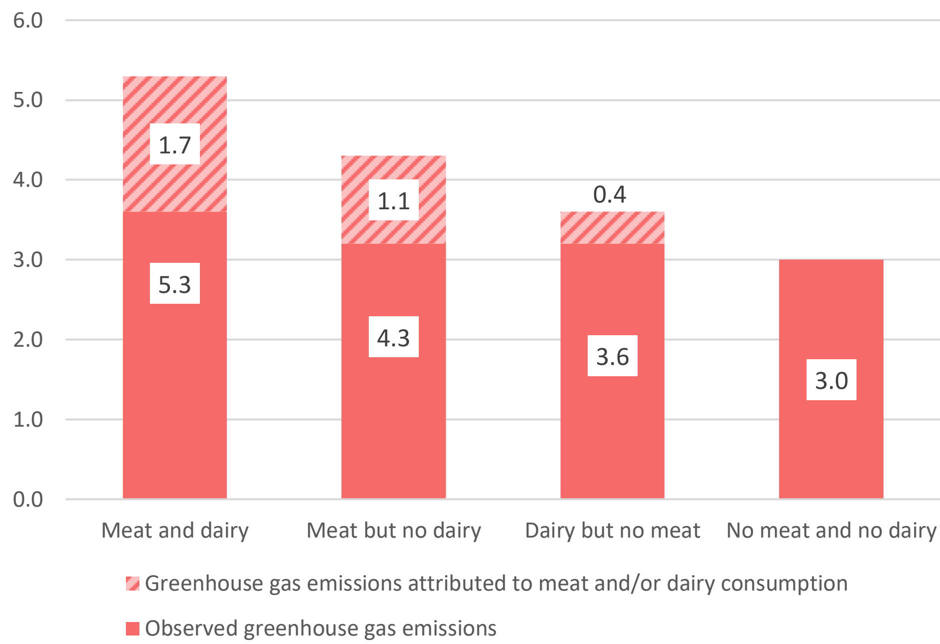
Regression Models

Meat and dairy consumption contributes substantially to dietary environmental impact. In addition, factors such as age, gender, education level, and migration background may also influence individuals' food consumption and thus the environmental impact of diets. It is, therefore, important to gain deeper insights into the extent to which meat and dairy consumption contributed to dietary environmental impact, irrespective of the influence of these other factors. To calculate this, two linear regression models were applied for all environmental impact indicators. Taking greenhouse gas emissions as an example, in the first model, the log-transformed values of the greenhouse gas emissions of daily diets were set as the dependent variable, while age, gender, energy intake, education level, migration background, and meat and dairy consumption (both amount and consuming meat and dairy on an assessment day or not) were set as the independent variables. The second model was identical but the variables for meat and dairy consumption were left out, i.e., it included age, gender, energy intake, education level, and migration background as the independent variables. The difference of the greenhouse gas emissions predicted by these two models thus estimated the part of dietary greenhouse gas emissions that can be attributed to meat and dairy consumption. For other environmental impact indicators, the same approach was applied.

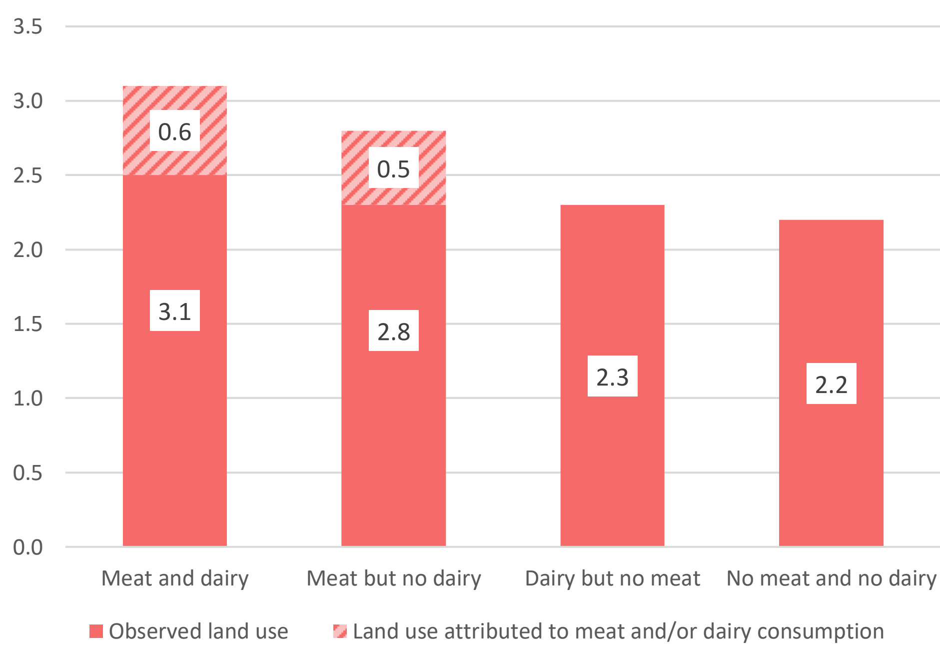
The estimated environmental impact attributed to meat and dairy consumption is shown in **Figure 2**. In the figures, the total height of each stacked bar represents the observed values of environmental impact on days with and without meat and dairy consumption, while the shadowed areas denote the estimated environmental impact attributed to meat and/or dairy consumption. For blue water use, the shadowed areas however denote the estimated blue water use attributed to not consuming meat and dairy, in reference to days with meat and dairy consumption. Of all consumption days, meat and dairy consumption in total (the left bars in each figure) was estimated to account for 1.7 kg CO2-eq/day of greenhouse gas emissions, 0.6 m^2·year/day of land use, 25.8 kg SO2-eq·10^{-3}/day of terrestrial acidification, 6.2 kg Peq·10^{-5}/day of freshwater eutrophication, and 3.4 kg Neq·10^{-3}/day of marine eutrophication, whereas the consumption of meat alone (second bars from the left) or dairy alone (third bars from the left) contributed less to the overall environmental impact. On the other hand, meat and dairy consumption in total was estimated to result in 31.2 L/day less of blue water use, in reference to days without meat and dairy consumption.

Figure 2 – Estimated dietary environmental impact attributed to meat and dairy consumption

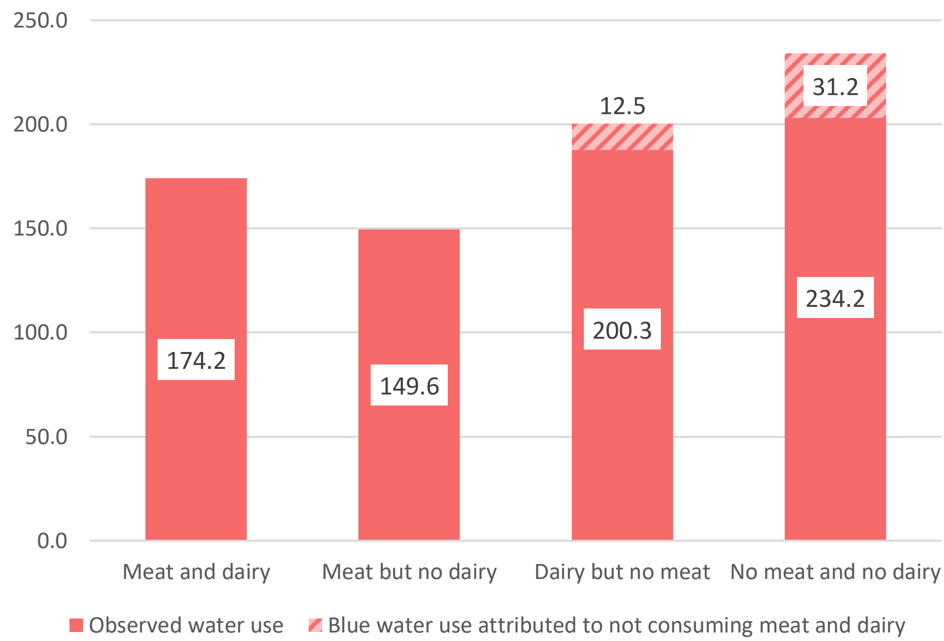
(a) Greenhouse gas emissions (kg CO2-eq/day)



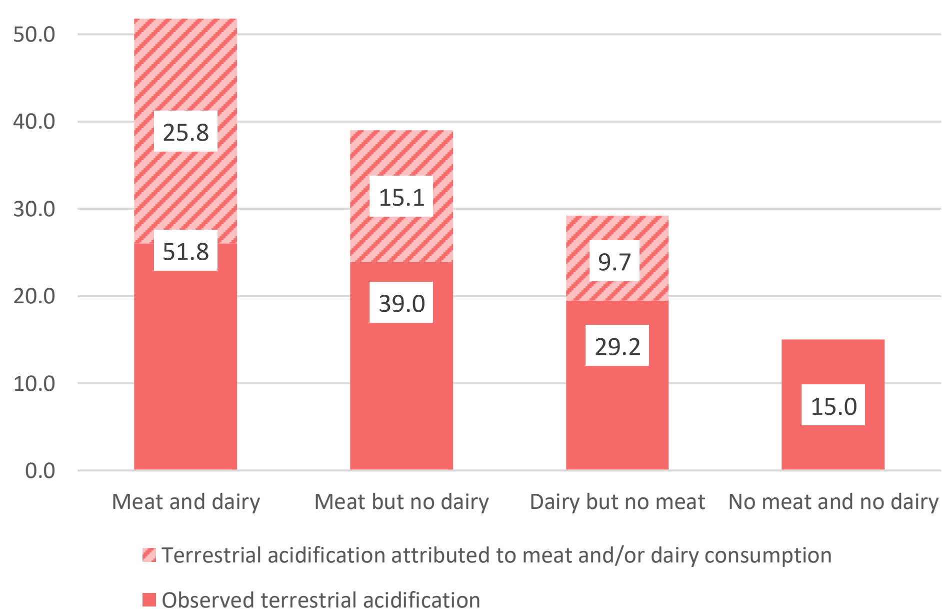
(b) Land use (m^2·year/day)



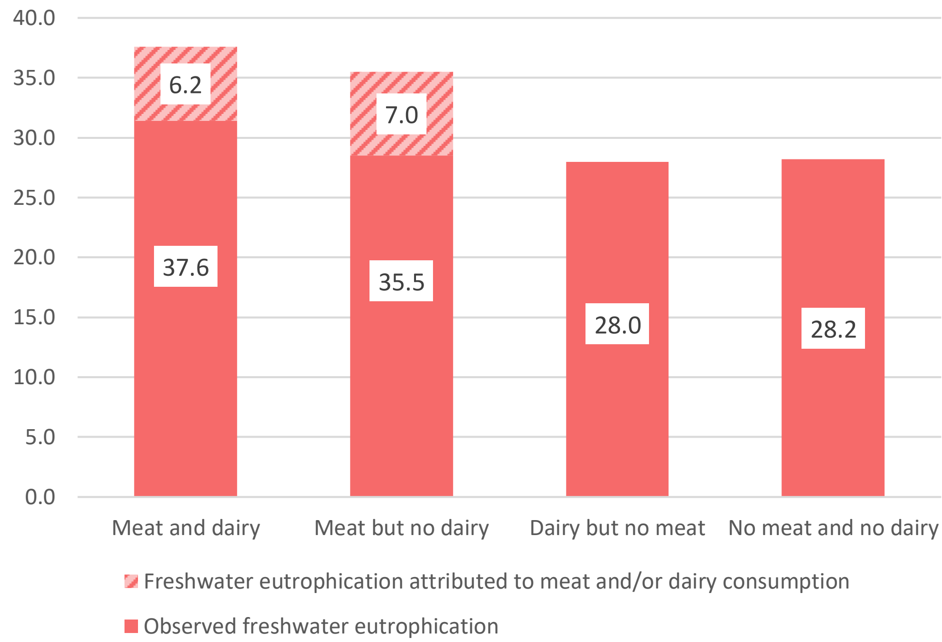
(c) Blue water use (L/day)



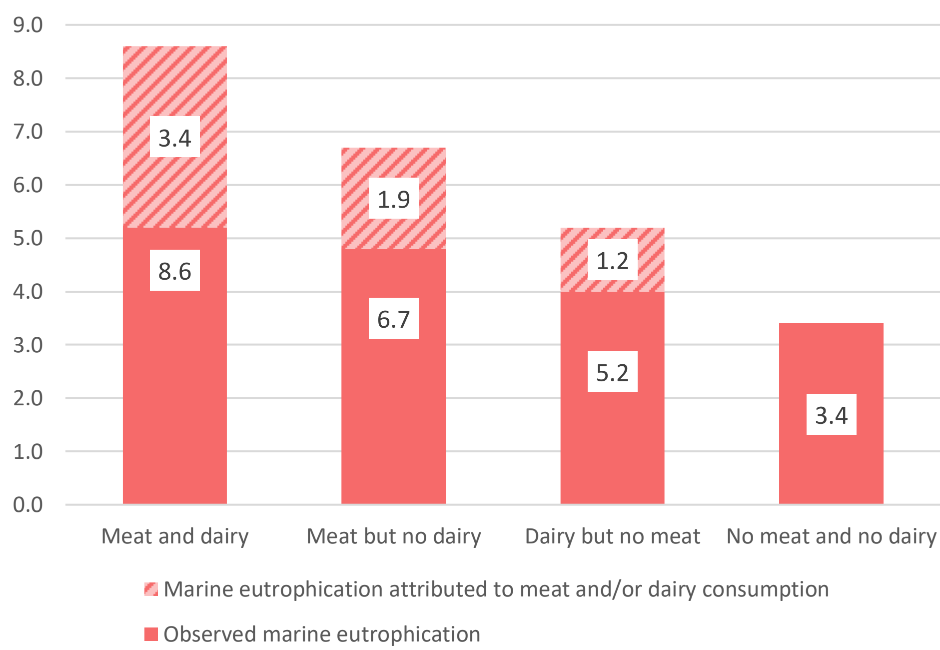
(d) Terrestrial acidification, kg SO2-eq·10^{-3}/day



(e) Freshwater eutrophication, kg Peq·10^{-5}/day



(f) Marine eutrophication, kg Neq·10^{-3}/day



Blue Water Use

The higher blue water use on days without meat and dairy consumption may result from the consumption of nuts/seeds, fats/oils, vegetables, and fruits. This finding is different compared with the previous study, which showed that on days without meat and dairy consumption, the blue water use was 27 L/day less than on days with meat and dairy consumption (Heerschop, 2022). **Table 5** shows the contribution of different food groups to the total blue water use across days with and without meat and dairy. On days without meat and dairy, the consumption of nuts/seeds (46.5 L/day), oils/fats (36.1 L/day), vegetables (28.1 L/day), and fruits (45.2 L/day) showed higher blue water use compared to days with meat and dairy consumption: nuts/seeds 15.5 L/day, oils/fats 10.9 L/day, vegetables 14.0 L/day, and fruits 29.2 L/day. On days with meat and dairy consumption, meat and dairy accounted for 17.0 L/day and 21.1 L/day of blue water use, respectively. The increase in blue water use linked to the consumption of nuts/seeds, fats/oils, vegetables, and fruits offsets the blue water conserved of not consuming meat and dairy.

Figure 3 displays the average consumption levels of meat and dairy replacers, vegetables, fruits, and oils/fats, categorized by days with and without meat and dairy consumption. On days with meat and dairy consumption, the average consumption of vegetables and fruits was 166.2 and 144.5 grams/day, respectively, which falls below the 2015 Dutch dietary guidelines recommending at least 200 grams of fruits and 200 grams of vegetables daily (Kromhout, 2016). Therefore, adhering to a healthy diet by increasing fruit and vegetable consumption may naturally result in higher blue water use. Previous research has also shown that higher adherence to the Dutch dietary guidelines correlates with increased water use in daily diets (Vellinga, 2019).

To achieve a healthy and sustainable diet, making smart choices for plant-based foods with lower environmental impact is crucial. On days without meat and dairy, the average consumption of legumes was 21.6 grams/day, compared with 6.4 grams/day on days with meat and dairy, resulting in a difference of 15.2 grams/day (**Figure 3**). However, this difference in legume consumption translates to only approximately 1 L/day difference in blue water use, with the blue water use being 1.5 L/day on days without meat and dairy (**Table 5**). Therefore, increasing legume consumption as a plant-based meat replacer can be beneficial for both health and the environment.

On the other hand, the consumption of exotic fruits, vegetables, and olive oil may lead to higher blue water use in daily diets. Regardless of meat and dairy consumption, the average consumption of oils and fats was approximately 20 grams/day (**Figure 3**). However, on days without meat and dairy, the blue water use attributed to oils and fats was more than three times higher than on days with meat and dairy. Accordingly, it is essential to reduce consumption of certain types of plant-based foods with high environmental impact and replace them with other similar plant-based options that have a lower environmental impact.

In the case of nuts, they generally show a higher blue water use compared with other plant-based meat replacers (Vanham, 2020). However, the blue water use per portion of nuts is relatively low (25 grams of nuts/seeds are one portion, equivalent to 100 grams of unprocessed meat). Excessive consumption of nuts is not recommended due to their high energy content (Voedingscentrum). On days without meat and dairy, the consumption of nuts and seeds was 36.9 grams/day, which is substantially higher than the current recommendation of 15 grams per day (Kromhout, 2016). Moderate consumption of nuts may thus help reduce the current observed higher blue water use.

Table 5 – Contribution of the consumption of different food groups to blue water use (L/day) on days with and without meat and dairy consumption[a]

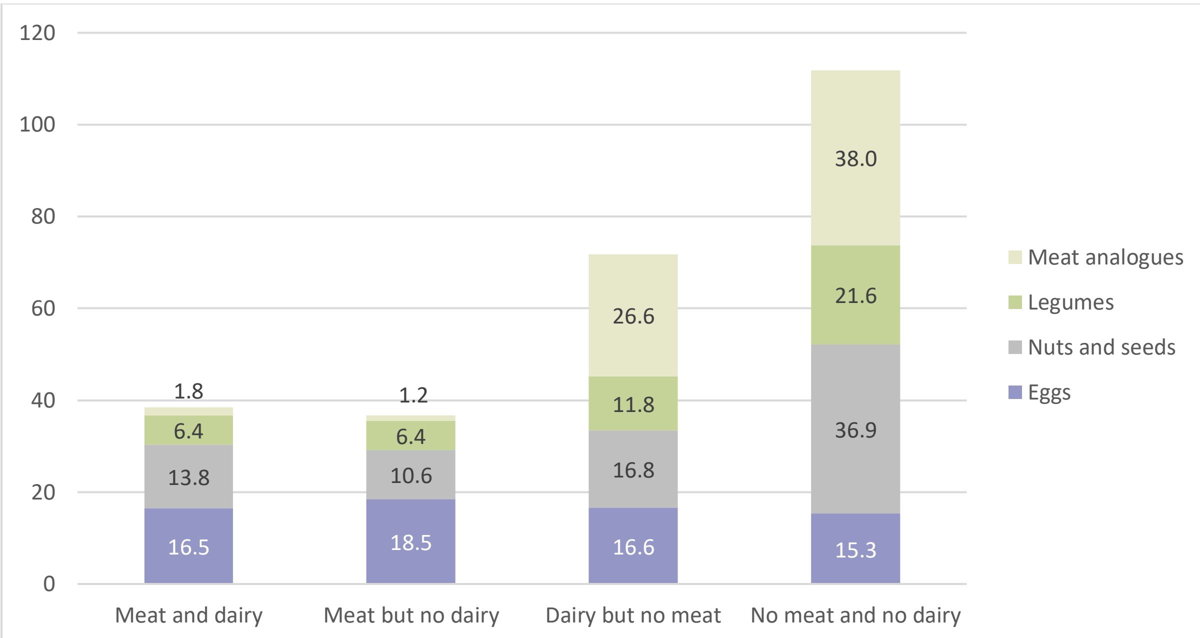
	Meat and dairy	Meat but no dairy	Dairy but no meat	No meat and no dairy
Meat replacers				
Meat analogues (vegetarian/vegan meat)	0.1 (0.8)	0.1 (0.8)	1.6 (3.0)	1.9 (2.5)
Legumes	0.5 (2.3)	0.5 (2.2)	0.8 (3.1)	1.5 (4.3)
Nuts and seeds	15.5 (43.2)	12.2 (48.3)	21.4 (51.2)	46.5 (89.0)
Eggs	1.8 (3.6)	2.0 (3.4)	1.8 (3.4)	1.6 (3.7)
Dairy replacers				
Plant-based dairy[b]	0.3 (3.7)	2.4 (13.3)	1.7 (9.8)	3.2 (7.7)
Coconut milk and sorbet	0.1 (0.5)	0.1 (1.1)	0.1 (0.5)	0 (0.1)
Non-dairy and non-alcoholic beverages	38.5 (41.6)	37.0 (44.6)	47.8 (50.5)	46.3 (51.7)
Alcoholic beverages	5.3 (11.5)	4.9 (10.9)	4.3 (9.1)	3.0 (8.2)
Oils and fats	10.9 (23.0)	14.1 (25.7)	18.5 (38.5)	36.1 (66.6)
Staples	9.5 (11.1)	11.2 (12.3)	9.2 (11.6)	11.1 (13.4)
Vegetables	14.0 (24.0)	15.6 (28.4)	20.7 (33.5)	28.1 (45.4)
Fruits	29.2 (40.6)	18.6 (30.0)	35.4 (42.6)	45.2 (59.0)
Sugar, confectionary, and sweets	6.3 (11.6)	6.0 (16.3)	6.5 (12.4)	4.5 (12.2)
Savory snacks	1.0 (2.7)	1.8 (4.1)	1.5 (3.4)	1.6 (3.2)
Meat	17.0 (13.4)	20.4 (15.1)	0	0
Dairy	21.1 (90.6)	0	24.7 (95.8)	0
Other foods and drinks	3.0 (6.9)	2.8 (3.4)	4.2 (15.3)	3.6 (3.8)
Total	174.2 (128.3)	149.6 (89.1)	200.3 (152.9)	234.2 (156.6)

[a] Data are presented as mean (standard deviation).

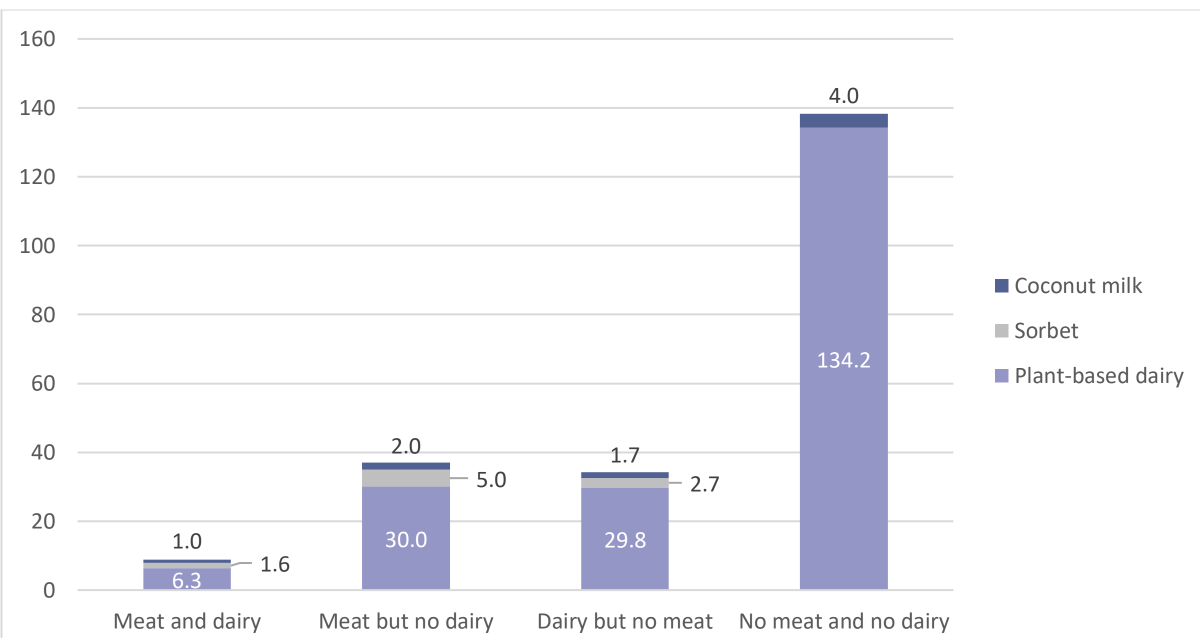
[b] Plant-based dairy includes soy milk, rice milk, almond milk, oat milk, soy yogurt, and other plant-based dairy products.

Figure 3 – Average consumption of meat replacers, dairy replacers, vegetables, fruits, and oils/fats (grams/day) on days with and without meat and dairy consumption

(a) Meat replacers

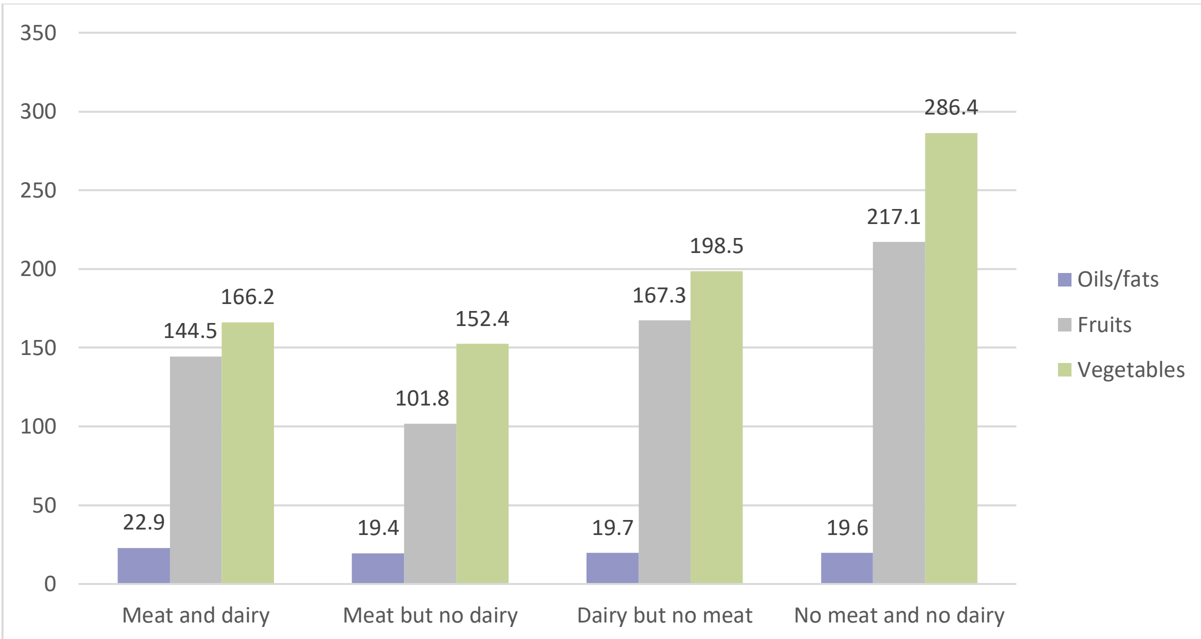


(b) Dairy replacers[a]



[a] Plant-based dairy includes soy milk, rice milk, almond milk, oat milk, soy yogurt, and other plant-based dairy products.

(c) Vegetables, fruits, and oils/fats



Other Considerations

This research estimated the potential reduction in dietary environmental impact that could be achieved if individuals replaced meat and dairy by meat and dairy replacers. The research is based on a cross-sectional food consumption survey; hence, real-life changes in diets and associated changes in environmental impact with longer period of time were not investigated; nevertheless, the calculations provide a reasonable estimate on to what extent a meat-free and a dairy-free day may help reduce the dietary environmental impact. When people change towards a habitual diet without meat and/or dairy consumption, they may also change other aspects of their dietary patterns, which could not be accounted for in this research. The alterations in the overall dietary pattern, including different choices and consumption levels of other food products, might also explain the higher level of blue water use observed on days without meat and dairy consumption. Nevertheless, the effects of long-term dietary adjustment on the environmental impact should be further studied.

Limiting meat and dairy consumption not only affects dietary environmental impact, but many other dietary factors as well. Sufficient intake of nutrients should be guaranteed when switching to more plant-based diets. Animal-based foods are good dietary sources of iron, calcium, vitamin B1, vitamin B12, and vitamin D, while in plant-based foods these nutrients are in general limited (Tso, 2021).

In this research, we showed potential reduction in dietary environmental impact for a day and a week by replacing meat and dairy by meat and dairy replacers. Our results suggest substantial long-term benefits may be achieved in reducing the environmental impact of diets, if individuals switch to more plant-based dietary patterns for a longer period of time. Moreover, the environmental impact indicators used in this research are based on current estimates related to the current production systems. Environmental footprints of food items will change when animal and plant/crops production systems become more environmentally sustainable.

Conclusions

In this research, we assessed the environmental impact of daily diets of Dutch adults and estimated the potential reduction in environmental impact that would be achieved if individuals replaced meat and dairy by meat and dairy replacers in their diets. Among all participants, the average meat and dairy consumption was 108.0 and 346.2 grams/day, respectively. Of the total 3494 days of dietary assessments, 432 (12.4%) days were meat-free; 199 (5.7%) days were dairy-free; and 45 (1.3%) days had neither meat nor dairy consumption. Days with meat and dairy consumption in general showed higher dietary environmental impact compared with days without meat and dairy consumption, with the exception of blue water use. However, making healthy choices of plant-based foods with lower blue water use (such as legumes) is possible. If individuals replaced meat and dairy with plant-based meat and dairy replacers, this change could lead to an average reduction of 2.1 kg CO2-eq/day (by 38.5%) in greenhouse gas emissions, 0.6 m^2·year/day (by 18.2%) in land use, 33.3 kg SO2-eq·10^{-3}/day (by 61.6%) in terrestrial acidification, 6.4 kg Peq·10^{-5}/day (by 15.3%) in freshwater eutrophication, and 4.5 kg Neq·10^{-3}/day (by 47.0%) in marine eutrophication. These findings show that limiting meat and dairy consumption in daily diets may have a substantial potential in reducing environmental footprints in this Dutch adult population.

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