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Environmental and financial impact of the current meat-based diet for the Zorggroep Drenthe

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January 19, 2024

Abstract

This report discusses a research about the climatic and financial impact of the meals served at the Zorggroep Drenthe. First, the reasons for this research and the problem will be elaborated on. Next, the research plan gives an outline of how the research was conducted and what variables were taken into account. Then, the model will be discussed and the results will be shown in the forms of weight, costs and CO2-equivalents, including a vegetarian and vegan scenario. Lastly, a discussion with several considerations and future research opportunities are given.

CONTENTS

Index Terms— **meat-based, plant-based, diet, environmental impact, CO2-e, emissions, GHG, vegetarian, vegan**

I. INTRODUCTION

The Zorggroep Drenthe (ZGD) is currently considering changing their diet from meat-based to plant-based meals. The cause of this transition to plant-based meals can be dedicated to the rising interest in climate change, resulting in an increasing number of organizations that are made accountable for their impact on global warming. Next to that, there are various health benefits from having a plant-based diet. It is already known that eating an abundance of red meat has some serious health concerns [1]. Some nutrients in red meat increase the chance of getting atherosclerosis. [2]. Also, vegetarians have a lower chance on heart disease due to lower blood pressure, compared to omnivores.[3] Even better, by implementing a more plant based diet there is correlation between fewer death rates and less GHG-emissions [4] .The ZGD would also like to contribute to minimizing their impact on the environment by changing their meals to a plant-based diet. In this research, the environmental as well as the financial impact of the current meat-based diet is investigated and vegetarian and vegan scenarios are explored.

Considerable research has already been done in this field. The research done by [5] did calculations on the climate impact of various diets. The results showed that an ordinary meat-based diet, on average, has more than 5 times the impact on climate change, compared to a vegetarian diet. According to [4] the environmental impact on a local scale from changing to vegan diets can be reduced by 29-70 percent compared to a meat-based scenario in 2050. It should also be noted that climate change caused by meat production is not only due to CO2-emissions. Article [6] shows that a change in diet from meat-based meals to vegan meals has more positive impact than only a decrease in CO2-emissions, but it also decreases the CH4 and NO2 emissions. Next to that land availability will increase. According to [7] ,"Food security and food sustainability are on a collision course. Changing course (to avoid the collision) will require extreme downward shifts in meat and dairy consumption by large segments of the world population" (Sabate, 2014). Article [8] confirms that in the current trend, available land for food production will only suffice if meat production is drastically decreased in the next decades. It is already known, that beef has the biggest impact on climate change of all the possible ingredients. [9].These articles illustrate the importance of a drastic decrease of meat production and thus meat consumption.

This research will focus on one location of the ZGD (Eelde), as well as a comparison between different locations of the ZGD and determine the environmental impact of the current meat-based diet for these locations, making this a concrete and well bound system. Although the focus will be on the location in Eelde, other ZGD locations will also be explored in order to confirm the reliability and generalizability of the model, with the main goal to proof the generality of the model, such that it can be used in different organizations. Since the ZGD has never done research into the field of emissions due to the diet, this research brings new insights for the organization.

This report is structured in the following way: First the problem is elaborated on via a why-what analysis and a stakeholder analysis. Then the problem statement is explored. After that, the research plan is elaborated on, which includes a research objective with research questions, a research framework and research methods. After this, the setup of the model will be explained and the results will be discussed via different scenarios. With this data, a decision tree is made, which gives a good overview on how to reduce GHG-emissions due too food consumption, followed by a discussion which gives several considerations and future research options.

II. PROBLEM ANALYSIS

A. Stakeholder Analysis

In order to properly understand the problem, one must understand who is affected by it. The stakeholder analysis is a tool to schematically view the stakeholders in one glance and can be seen in figure 1.

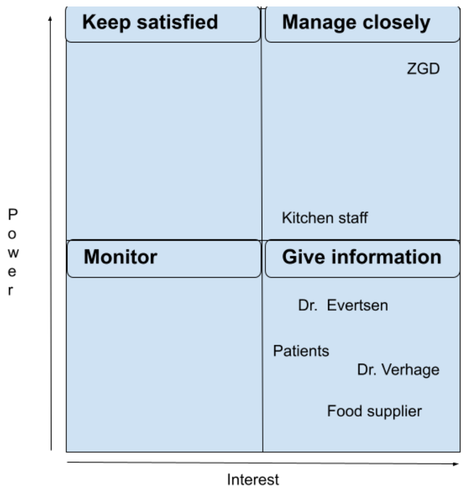

Fig. 1. Stakeholders of the diet change for ZGD.

Naturally, the ZGD is most invested in the problem because it is directly affected by the costs and it has all the power in this situation. The patients are directly affected by the change in diets, since they are the ones that eat the meals. Although the patients have no direct influence on the contents of their meal, it would be ethical to take their opinions into account, since on average, patients in this care group have nine months left to live. Given this fact, it would be ethical to still give these people the option of meat in their diet. If this institution had been taking care of long term patients, the possibility of making personal concessions about serving plant-based meals seams more ethical. According to the triple-P principle, planet, profit and people affected by the decision making should be equally important. However, as the protein intake from meat on the current path is not an option [10], eating plant-based meals is better for people in the long term. Next to that, the patients may have some influence, because if everyone hates the new vegetarian meals, the ZGD will be affected by it. Dr. Verhage is interested in the results because Dr. Evertsen requested that research should be done in this field of transitioning to plant-based meals at the ZGD Eelde. Moreover, Dr. Verhage is researching implementing plant-based meals on a more regional scale. Dr. Evertsen is the doctor who works on site in Eelde and knows the benefits of plant-based diets. Next to that, the process of researching vegetarian meals at the location in Eelde has been started by Dr. Evertsen contacting Dr. Verhage. The cooks have a big influence on the ingredients, as they are allowed to order whatever they want. Naturally their interest is also high since they are preparing the meals. Lastly, the food supplier may be affected, because the ZGD may have to change supplier if the current one does not have the proper ingredients for vegan meals.

B. Why-what Analysis

A why-what analysis is used to explore the context. The why questions are asked in order to broaden the context of the problem by asking why there is a need for plant-based meals. The what questions are asked in order to narrow the scope down by asking exactly what is stopping us from solving the problem right now. The analysis can be seen in figure 2.

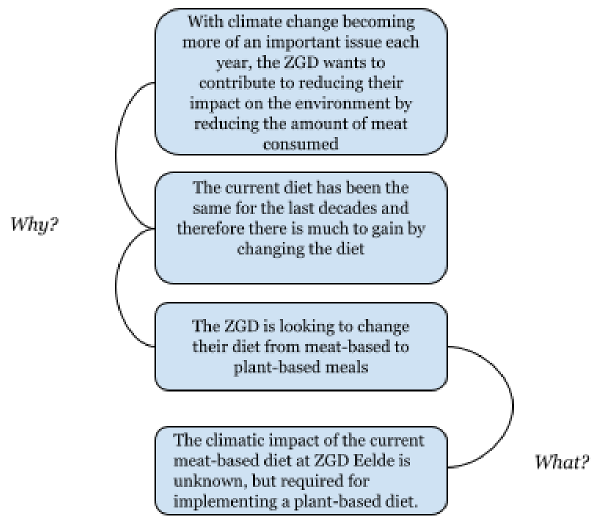

Fig. 2. A why-what analysis for the current meat-based diet for ZGD.

C. System Analysis

To understand the relations in the system, a system analysis was done using the objective tree methodology, which can be seen in figure 3. Measurable outputs are:

1) Cost statistics: The amount of money in Euros each class has cost in a period of a month.
2) CO2-e statistics: The amount of CO2-e each class is responsible for in a period of a month in kg.

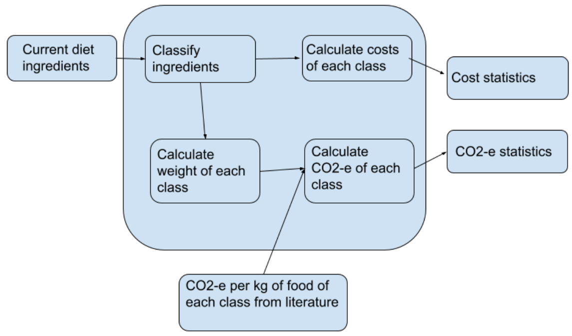

Fig. 3. A system analysis for the calculations on the diet for the ZGD

D. Problem Statement

The meat production industry is starting to experience pressure to minimize their production due to their significant contribution to climate change, resulting in increasing prices for meat in the next decades. The ZGD currently still serves meat-based meals on a daily basis and is looking for other options in their diet. The following problem statement has been determined: *The climatic impact of the current meat-based diet at the ZGD is unknown and food classes in which the most GHG-emissions reduction can be made are required, before a more sustainable plant-based diet can be implemented.* It should be noted that Dr. Verhage accepted the challenge of implementing plant-based diets on a more regional scale in the health care sector, and is therefore the problem owner in this research. Dr. Evertsen could be considered the problem owner, but in the long run this research will affect more than solely the location in Eelde, therefore Dr. Verhage is more interested and affected by the results and is considered the problem owner.

III. RESEARCH PLAN

A. Research Objective

The following research objective (RO) has been determined: **Develop a model which can estimate the GHG-emissions and costs, based on a list of specific ingredients used for the meals prepared for the ZGD, by January 2024**. As said before, Dr. Verhage is the problem owner and is looking to implement plant-based diets in the health care sector. However, before being able to make such drastic changes, the climatic impact of the current diet needs to be investigated. This research can be seen as a baseline measurement for future research of Dr. Verhage. The baseline measurement was calculated via a model in Microsoft Excel, where the input is a list of ingredients categorized into classes. The impact on the environment was measured in a term called CO2-equivalent. ""Carbon dioxide equivalent" or "CO2-e" is a term for describing different greenhouse gasses in a common unit. For any quantity and type of greenhouse gas, CO2-e signifies the amount of CO2 which would have the equivalent global warming impact." (Brander, 2023)[11]. These gasses are factored according to the global warming potential (GWP) because not every gas has the same impact on global warming, resulting in a clear schematic overview of the climatic impact per food class. To check whether the research objective is effective, the S.M.A.R.T. tool is used:

- Specific: The RO is specific, since the research is constrained to the ZGD's locations with a concrete diet.
- Measurable: The RO will be measured in CO2-equivalents.
- Attainable: With the current knowledge about the impact of various meat-based diets as well as the impact of the greenhouse gasses, the RO is attainable.
- Relevant: Due to the meat production's high impact on climate change, and the ZGD's willingness to change their diet, this RO is relevant.
- Time-bound: An end date is set, resulting in a time-bound RO.

B. Research Framework

The research framework makes clear whats steps had to be taken in order to successfully complete the RO. The research framework is given in figure 4. First of all, the exact diet

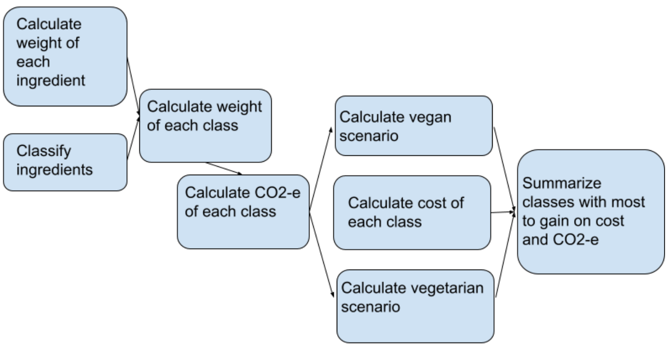

Fig. 4. Research Framework showing the steps required to achieve a schematic overview of the climatic and financial impact of the ZGD's current meat-based diet.

needs to determined, before any research can be done. After this, the climatic and financial impact of these diets can be determined by using a model in Excel which can calculate the CO2-e for each food class, if the mass of that class is given. Not every unit of measure is that of mass, therefore some units need to be converted from volume to mass or from "pieces" to mass. There is no universal conversion for this operation, since foods have different densities, and the unit of pieces had to be converted manually. When this is done, the amount of emissions needs to be calculated for each food class. After this, the different scenarios can be explored in order to obtain information about the differences in costs and CO2-e. Combining all this data will yield a schematic overview of the diet.

C. Research Questions

The following research questions have been identified:

1) What food is served at the ZGD Eelde?
2) What is the emission of each food class in terms of CO2-e?
3) Which specific ingredients have the most potential for emissions reduction?

D. Research Methods

First of all, desk research was required for relevant literature regarding the emissions of each type of ingredient. Considerable papers are available on the emission of meat as well as vegetables in terms of CO2-equivalent. However, some papers have been written commissioned by companies producing the ingredients, decreasing the trustworthiness of the LCA's done in these papers. In order to get an accurate CO2-equivalent, these papers were reviewed intensively before considering them useful for this research. Also, an average of multiple papers were taken in order to decrease the error margin. Additionally, data is gathered by having conversations with the chef and Dr. Evertsen at the location in Eelde. This going out into the field can be considered empirical research.[12].

IV. The Model

When the information above has been obtained, the data of the ZGD will be used in a model in Microsoft Excel to calculate the CO2-equivalent of the ingredients. These ingredients have already been divided into several classes by the ZGD:

- Potatoes, vegetables and fruits
- Butter,cheese, eggs and oils
- Bread
- Dairy
- Meat and fish

Unfortunately, the accuracy of these classes was not sufficient in order to directly copy them into the model, because several significant mistakes were found in classification. As a consequence, the ingredients had to be classified manually, which was an extremely time consuming operation. If the need arises to model more locations, of course it is possible to classify these orders later on. Some classes have been purposely excluded from the calculations. All non-food orders are excluded, since this does not affect the dietary emissions. Next to that, prepared meals are included in the orders of each location, however these meals are specific orders by patients, or orders placed by doctors for a specific patient with special dietary needs. For this reason, the prepared meals are also excluded from the calculations. Next, pastry and sweets are excluded from the calculations for two reasons. The first being the enormous amount of research it would require to track down every ingredient in each type of pastry and do LCA's on them. Secondly, pastry is not considered part of the standard diet but are snacks which not every patients consumes. For this same reason coffee and tea products have been excluded from the calculations. It should be noted that coffee does have a relatively high impact on the environment in terms of GHG-emissions, which is 15.3 kg CO2-e per kg of coffee. [13]. Lastly sauces, soups and special ingredients as gravy have been excluded, for the simple reason that these products cannot be classified in one the predetermined classes. Also, since the impact of these products vary, they cannot be classified into a 'remaining' class. This will not affect the overall results, as first of all it is mostly made from vegetables which have a low CO2-e per kg of product. Secondly, since the total weight of these excluded items is negligible compared to the weight of the other vegetables.

Once these classes of food have been obtained, the mass of each class needs to be calculated, after which these values can be put into the model. The output will be a CO2-e value in kilograms for each food class. However, before analyzing the preliminary results, a couple of factors should be taken into consideration. The data sheet obtained from the ZGD with the given products for each location and each month, is expressed in the following units: g, kg, L, ml, cl and pieces. As the CO2-e values will be calculated in terms of kg, these units had to be converted to kg. For the sake of convenience 1 Liter has been assumed to be 1 kg. This rounding can be considered negligible as most units of volume come from dairy products and 1 liter of milk has a mass of 1.035 kg. As for the unit 'pieces', each product had to be researched manually as to what the mass of those products were. This was especially the case for animal products, since these ingredients do not have a standardized weight.

When this data has been converted, the model can be used to calculate the total CO2-e values for each food class. The amount of CO2-e per kg of food used in the calculations can be seen in Table I. [14] [15] [16] [17] [18] [19] [20] [21] [22] [23]

TABLE I
CO2-E (KG/KG FOOD) FOR EACH FOOD CLASS

Potatoes	0.35
Vegetables	0.53
Fruit	1.05
Butter	10.91
Cheese	12
Eggs	3.45
Oil	3.81
Bread	0.82
Dairy	1.33
Beef	30.55
Pork	16.83
Poultry	4.33
Fish	4.7
Meat-free alternatives	2.2
Game meat	0.50

V. RESULTS

The results of this report can be divided into four different sections. The first section is a case study of the location in Eelde. For this section 4 months of orders have been classified and the units have been converted to kgs. The second section is a comparison of different locations of the ZGD, but all of the month November. The third section is a vegetarian scenario where all meat has been replaced by meat-free alternatives. Lastly, the fourth section is a vegan scenario where all animal products have been replaced by alternatives.

A. ZGD Eelde

The converted masses of each food class for each month can be seen in figure 5.

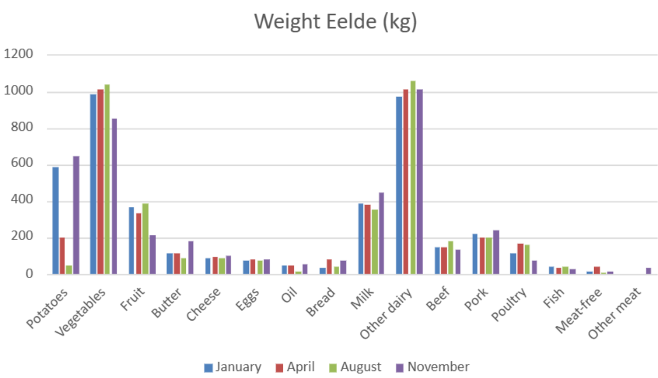

Fig. 5. Column graph displaying the amounts of food ordered in kg for four different months at the location in Eelde.

Notice that overall, the differences in orders between each month are exceptionally small. It can be concluded that the diet at ZGD Eelde is extremely consistent over the entire year. The biggest orders in terms of weight are vegetables and other dairy, which both are approximately a 1000 kilograms per month. With the data from figure 5 and table I the CO2-equivalents are calculated and are shown in figure 6.

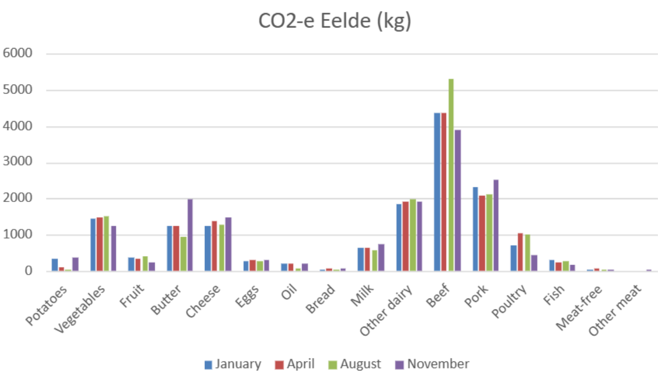

Fig. 6. Column graph displaying the CO2-equivalents in kg for four different months at the location in Eelde.

From this figure, it can be seen that the meat-consumption has the most impact on the CO2-e emissions by a long shot,

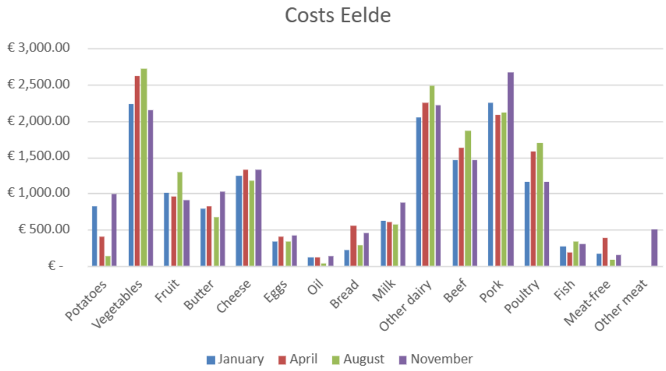

Fig. 7. Column graph displaying the costs in Euros for four different months at the location in Eelde.

after which dairy products come second. Beef alone has a CO2-e of 4474 kg after which pork comes second with a CO2-e of 2251 kg. It should be noted that the meat, which is 13 percent of the food in weight, contributes for 50 percent of the entire CO2-e. This result confirms the research mentioned before in the introduction. Lastly, the costs of these food classes have been identified and are shown in figure 7.

It can be seen that vegetables have the highest cost of 2432 Euros, but since this class takes up around half the orders, this is not unexpected. If milk were to be combined with the other dairy class, this class would have the biggest expense with a cost of 2920 Euros. Next to that, meat stands out once again by taking up more than one-third of the total costs. If other animal products such as dairy, butter and cheese are also included it will take up over 70 percent of all costs.

B. ZGD Different Locations

In this section, multiple locations of the ZGD will be compared according to the same benchmarks: Weight, Costs and CO2-e. All the calculations have been done the same as before, but solely for the month November. First the weight of each class was calculated, which can be seen in figure 8.

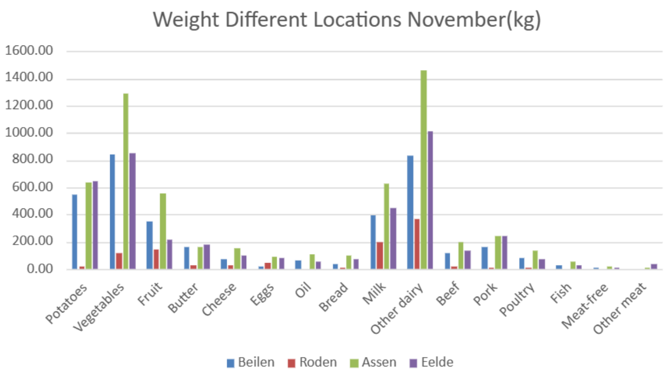

Fig. 8. Weight of each class for different locations of the ZGD for the month November in kg.

From this graph it can be deduced that there exist an overall trend in the weight of food class orders, with the exception of the ZGD Roden. This can be explained by the small number of patients present at this location, making it an unfit location for reliable results. Apart from this anomaly, the different locations all seam to have a linear relationship. This is expected to be true to the number of patients present at each location, since the menus for each location are the same. With these weights known, once again the CO2-e values were calculated and can be seen in figure 9.

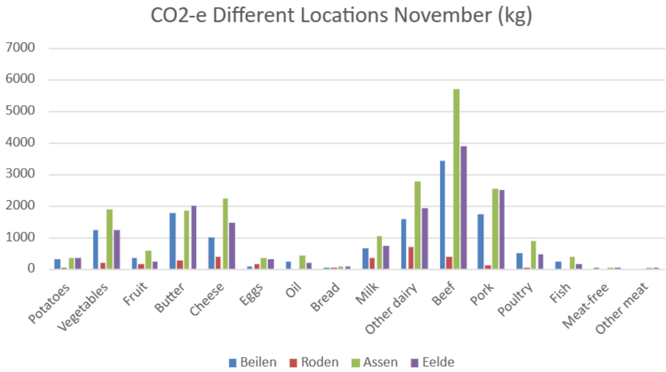

Fig. 9. CO2-e of each class for different locations of the ZGD for the month November in kg.

The first thing to notice is that beef once again has the biggest impact on climate change, with an average CO2-e of 3357 kg. Where other dairy comes second with a CO2-e of 1735 kg and pork comes third with a CO2-e of 1725 kg. The same conclusions as with the location in Eelde can be drawn; Meat is by far biggest contributor of GHG-emissions, after which animal products such as dairy butter and cheese come second. Lastly the costs were calculated, which can be seen in figure 10.

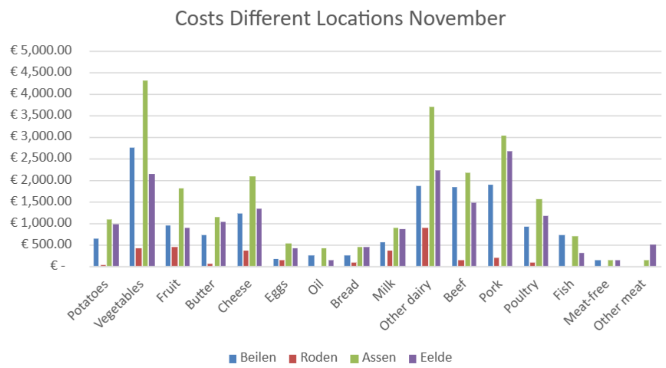

Fig. 10. Costs of each class for different locations of the ZGD for the month November in Euros.

As for comparing costs per food class over different locations, these statistics resemble the statistics of Eelde, where the vegetables class has the biggest cost of 2407 Euros. Again, other dairy comes second with a cost of 2168 Euros and animal products are the main expenses by a significant margin.

C. *Vegetarian Scenario*

One can imagine a scenario where all the mass in meat will be replaced with meat-free alternatives, rendering the diet vegetarian. This scenario has been modeled by replacing the average mass of all the meat by meat-free alternatives of which the CO2-e values can be seen in figure 11. Note that no nutritional aspect has been taken into account by replacing meat with meat-free alternatives.

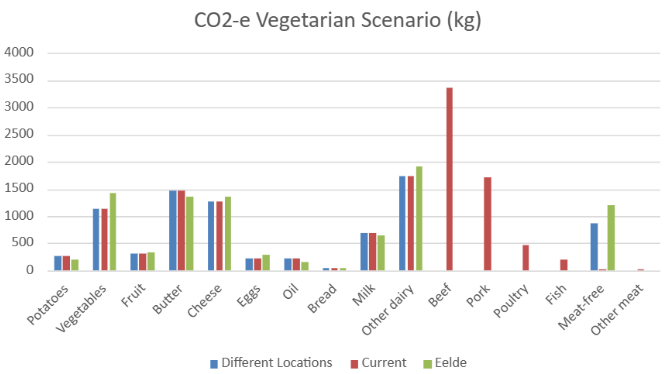

Fig. 11. Column graph displaying the CO2-equivalents for the ZGD, if the diet was vegetarian.

The first thing to notice, is that although all the meat has been replaced in weight, the CO2-e of the the meat-free alternatives is, on average, only 874 kg. when comparing this to the CO2-e of all the meat currently, which is 5763 kg, a decrease of 85 % in the meat sector can be seen. This results in a total decrease of 37 % in CO2-e. With the benefits of a vegetarian diet in terms of CO2-e known, the costs of this scenario were calculated and can be seen in figure 12. For the costs calculations of the meat-free alternatives, an average has been taken of the four different locations, which resulted in a cost of 12.44 Euros/kg.

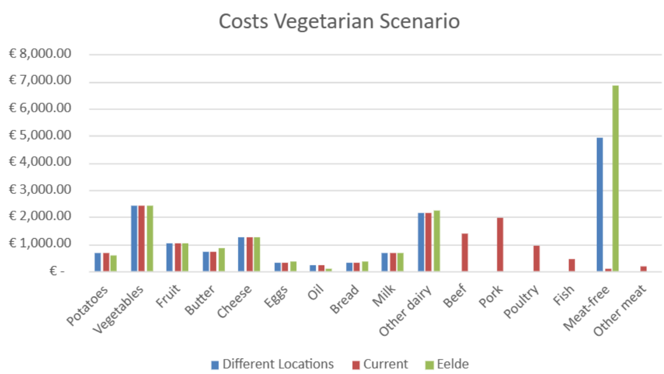

Fig. 12. Column graph displaying the Costs for the ZGD, if the diet was vegetarian.

It can immediately be seen that the meat-free alternatives are now the biggest cost of all classes with a cost of 4945 Euros. This huge rise is expected, since it replaces almost 389 kg of meat. However, when comparing the vegetarian total cost to the current total costs, a decline of 0.2 % can be seen. This implies that the price of meat-free alternatives is very similar to that of meat.

D. *Vegan Scenario*

One step further can be taken, by not just eliminating meat, but also eliminating products originating from meat, rendering the diet vegan. The values used for these vegan calculations can be seen in Table II. [24] [25] [26] [27] The costs have been determined by taking an average of the two biggest supermarket chains in the Netherlands: Albert Heijn and Jumbo. The results of this scenario can be seen in figure 13. Note that also for this scenario no nutritional aspect has been taken into account, only the weight has been replaced by its vegan alternative.

TABLE II
CO2-E (KG/KG FOOD) AND COST (EUROS/KG FOOD) FOR THE VEGAN SCENARIO

Meat-free alternatives	2.2 kg	€ 12.44
Dairy Replacement	0.341 kg	€ 1.75
Vegan Butter	3.3 kg	€ 9
Vegan Cheese	2 kg	€ 9
Vegan Eggs	0.92 kg	€ 20

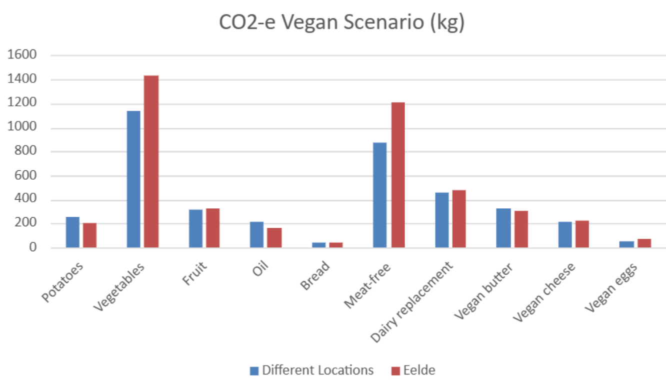

Fig. 13. Column graph displaying the CO2-equivalents for the ZGD, if the diet was vegan.

It can be seen that no class exceeds the CO2-e of vegetables anymore, which is 1140 kg. The total CO2-e of all classes have been reduced to 3895 kg. This is a reduction of 70.3 % compared to the current diet. Lastly, the costs have been calculated for the vegan diet, which can be seen in figure 14.

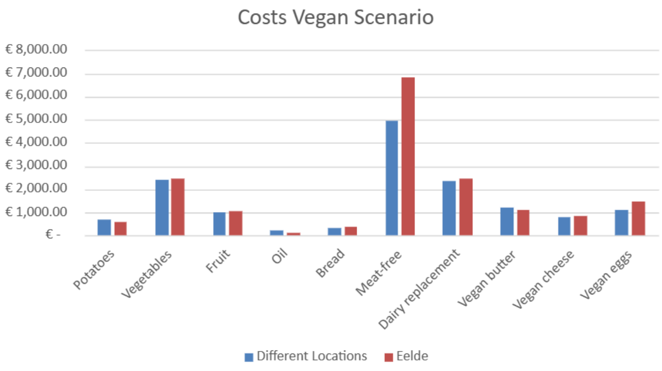

Fig. 14. Column graph displaying the Costs for the ZGD, if the diet was vegan.

The meat-free alternatives are still the most costly class, since this class has a relatively high weight as well as cost per kg. The cost increase for the vegan alternatives is not significant, with the exception of eggs. However, eggs are relatively low in weight, resulting in a total cost increase of 1.9 % for the vegan diet compared to that of the current diet.

VI. DECISION TREE FOR MINIMIZING CO2-E

In order to get a clear overview of what the impact is in GHG-emission reduction per food class, a decision tree has been made. This tree is based on the following data:

- ZGD Eelde November CO2-e
- ZGD Roden November CO2-e
- ZGD Beilen November CO2-e
- ZGD Assen November CO2-e

The purpose of this decision tree is to get a complete overview of what the impact of each food class is and how to minimize the CO2-e for the entire ZGD, while keeping costs under constraints given by management. The order of decision-making has been based on descending CO2-e/kg food. The decision tree can be seen in the Appendix, figure 15.

VII. DISCUSSION

From these results, several conclusions can be drawn. First of all, although the number of data sets to compare is small, it can be concluded that the overall diet is reasonably consistent over the year as well as over different locations. Because of this, it can also be concluded that beef has the most potential for emission reduction, however meat generally is the most suitable for reducing GHG. Animal products are the main contributor to GHG-emissions of the diet of the ZGD, as the vegan scenario had a CO2-e reduction of 70.3 percent and the vegetarian scenario a CO2-e reduction of 37.2 percent. Both these scenarios had a cost variation of less then 2 percent compared to the current diet. Lastly, animal products are also the main expenses of the diet of the ZGD, giving these classes the most potential in terms of cost as well as GHG-emission reduction.

It should be noted that several uncertainties arise when connecting GHG-emissions to food usage. First of all, getting an accurate picture of the exact diet is difficult, since the orders contain a lot more than simply ingredients for breakfast, lunch and dinner. They also contain, coffee, thee, pastry, snacks, kitchen appliances and already finished foods as soups and sauces. Filtering these classes out does come with the consequence of a higher probability of mistakes and thus higher error margins. Then there is the issue of drained weight with canned foods, which sometimes had to be estimated. Next to that, the CO2-equivalents used in the calculations are prone to a high error margin themselves, since literature is not particularly agreed upon these values, especially when it comes to animal products. Lastly, for these calculations the CO2-e for dairy herd has been used for beef, which of course is not true for all pieces of beef. This can make a huge difference, since the CO2-e for beef herd is double that of the dairy herd, especially considering beef already plays a big role in the CO2-e calculations.

Some recommendations for future research are to limit the number of food classes to the ones the study is interested in. This study separated milk from other dairy, without any new insights, thus spending a lot of time on needless data processing. Also, one might get a more holistic overview if calculations were done on the categories left out in this research. A next step before implementing a plant-based diet would be to research the nutritional benefits or disadvantages of vegetarian and vegan diets. Also, interviews with personnel and patients of the ZGD about implementing plant-based diets to find out the willingness to adapt to these new meals would be insightful.

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VIII. APPENDIX

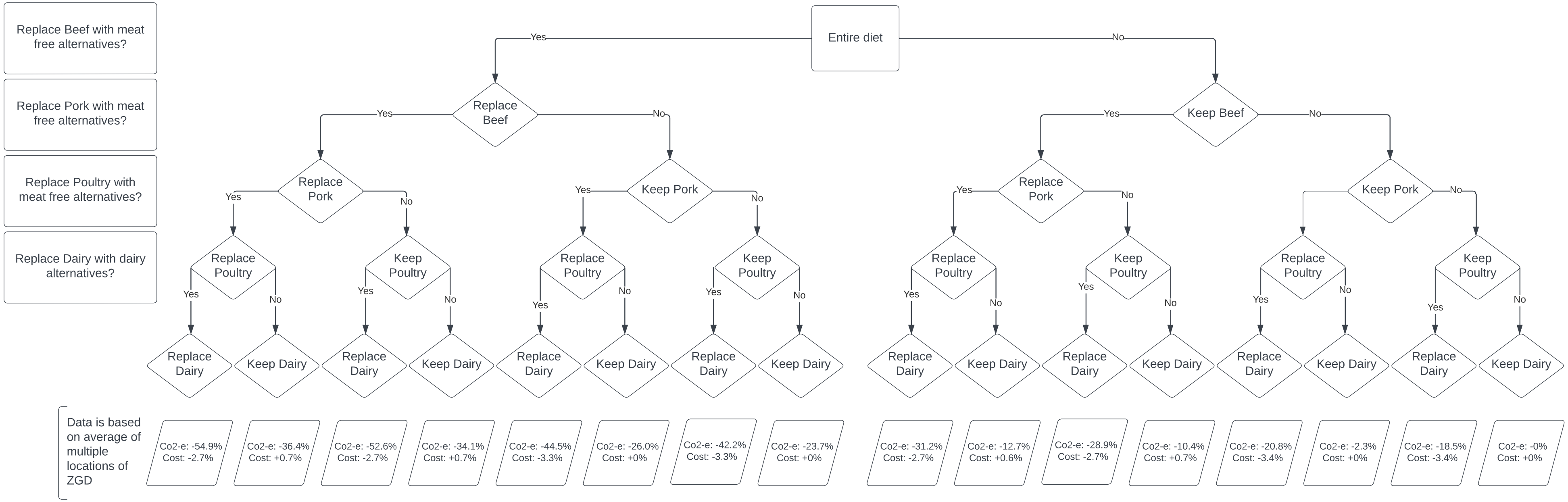

Fig. 15. Decision tree for eliminating animal products from the diet of the ZGD.