Aalto School of Science

Aalto University
School of Science

CS-E4450 - Explorative Information Visualization

Final report and visualisation

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Contents

1 Introduction

1.1 Topic

I would like to aware people on the negative effects that livestock farming has on the planet in terms of water scarcity, deforestation and Green House Gas (GHG) emission. In this project, I will particularly focus on GHG, and illustrate in an interactive way the carbon footprint of an individual according to his frequency of meat consumption. The goal is to make everybody understood the importance of dietary change in order to personally contribute to the resolution of climate change.

1.2 Motivation

My keen interest in climate change comes mostly from my unconditional love for traveling. Since I am a child, I travel the world with my family and have the chance to see amazing landscapes, islands and species that this amazing planet shelters. I am very grateful for that and I want to be able to offer the same experience to my children.

Now, why would I like to tackle livestock farming and not other important causes responsible for climate change (electricity generation, transportation, manufacturing...)? There are two reasons. First, I feel like very few people are truly conscious that livestock farming is responsible for a huge part of GHG emissions in the atmosphere. In other words, a lot of people do not realize to what point eating meat on a regular basis influences in a bad way climate change. Second, out of all the different causes of climate change, I feel like changing one's eating habits is probably the simplest but though impactful to consider if somebody wants to help solving climate change.

2 Approach

2.1 Discussion

From the beginning, it was very clear for me that my visualisation would contain objects or activities people are familiar with, so that the story behind it will be much more shocking. To give an example, an impactful comparison could be to show people how many hot-air balloons represent eating beef every day for a year in terms of GHG emissions. This type of comparison is, in my opinion, the one that people remember the most. My goal was to find a similar comparison that would integrate both time and space.

2.2 Tools

Eventually, I would like to tell a complete story around my visualisations, that is put them into context with text explanations. The most obvious and user-friendly way of achieving that is to build a well-designed website.

Programming a website with complex interactive applications is far to be trivial and requires advanced skills in JavaScript/CSS. As my background did not provide me with these skills, I turned towards an amazing Python graphing library called `plotly`, which allowed me to implement my visualisations with Python, and then export it to an HTML format that could later be embedded into my website.

In this manner, I implemented my visualisations with Python scripts, within Jupyter notebook, using mainly the following libraries:

- `pandas`: for manipulating data sets (cleaning and processing) in Python.
- `numpy`: for performing computations or operations with arrays in Python.
- `plotly`: for implementing beautiful and interactive visualisations with Python.
- `jupyter`, `ipython`, `ipywidgets`: for interactive computing in a Jupyter notebook.

2.3 Data

The data used in this project is varied. The first source of data comes from a study [1] conducted by two researchers from Oxford University, J. Poore and T. Nemecek, whose interest was to answer the following question: what is the best way to reduce food's environmental impacts? Poore and Nemecek consolidated data on the multiple environmental impacts of 38,000 farms producing 40 different agricultural goods around the world in a meta-analysis comparing various types of food production systems. Their study has been widely validated and considered seriously in the environmental community, and that is why I decided to trust their results. My first visualisation, described in Section 3.1, considers the results of this paper as its only data source.

The second visualisation however, described in Section 3.2, considers additional data sources:

- *GlobalAirportDatabase* [2]: a data set gathering information about 9,300 airports from all around the world. Each airport is described by its geographic coordinates (longitude, latitude), name, country, city and altitude.
- *British Nutrition Foundation* [3]: a table gathering protein content of some common foods found in the diet. The values that interest me in this table concern the "Meat" column describing the amount of protein found in beef, chicken, pork and lamb.
- *Carbon Independent* [4]: a calculator of CO2 emissions for a flight by plane. According to their hypotheses, the CO2 emissions from a Boeing 737-400 are 115 g per passenger km, and that is that number that I consider for the computations in my second visualisation.

3 Visualisations

As previously mentioned, I created two visualisations: a first one to illustrate the importance that meat consumption (particularly beef and lamb) have on the total amount of GHG emissions, and a second one to show in an interactive way the carbon footprint of somebody depending on one's consumption of meat (type of meat and frequency of eating per week).

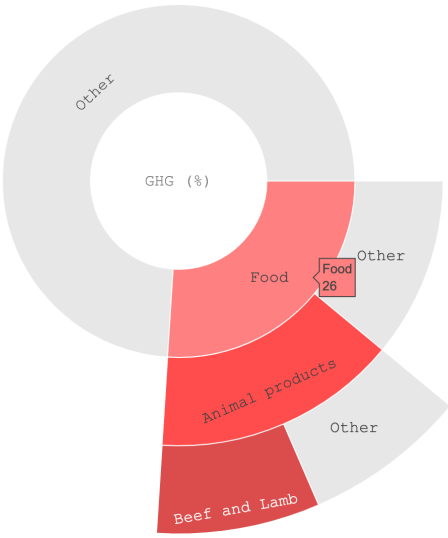
3.1 Sunburst Chart

This first visualisation illustrates in a simple way my motivation for choosing livestock farming as my subject of interest. It shows in a hierarchical way how significant consuming animal products - especially beef and lamb - contribute badly to the climate change.

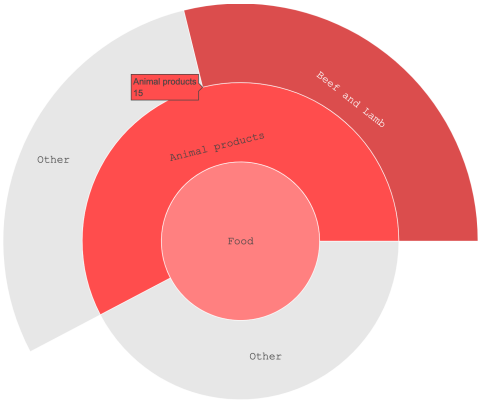
Figure 1 contains three screenshots of the visualisation, one for each stage of the animation. Initially, the user sees Figure (1a), illustrating the role that food plays in terms of Green-House Gas (GHG) emissions. By pointing the mouse at the different parts of the chart, a number representing the exact contribution in percent appears on the screen. For example, one can see that the food sector is responsible for 26% of the total GHG emissions.

By clicking on the *"Food"* section, the sunburst chart rotates such that *"Food"* becomes the center of the chart. Actually, the visualisation could be thought as a binary tree where each click on a section would correspond to going down by one level in the tree, focusing on the particular section we clicked on. Hence, in Figure (1b), one can see by pointing the mouse on *"Animal products"* that the latter is responsible for 15% of the total GHG emissions, which is huge in my opinion and should make people think about it. A last click on the *"Animal products"* part leads to Figure (1c) emphasizing the fact that among all animal products - gathering milk, eggs, meat, cheese, etc - beef and lamb meat is responsible for 7.5% of the whole GHG emissions, which is absolutely insane when comparing it to the whole transportation industry for example - planes, boats, cars, etc - that counts for 14% of the GHG emissions.

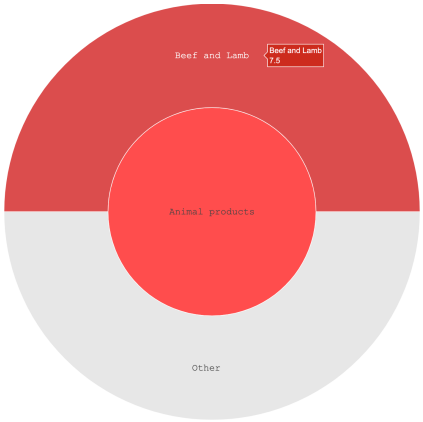
A demo of this visualisation is available here. Also, feel free to run the visualisation by yourself with this Jupyter Notebook (a `README.md` at the root of the github repository explains the different steps and requirements for the visualisation to work properly).



(a) Initial figure



(b) After clicking on "Food"



(c) After clicking on "Animal products"

Figure 1: Green-House Gas (GHG) emissions related to the food sector

3.2 Interactive World Map

3.2.1 Description

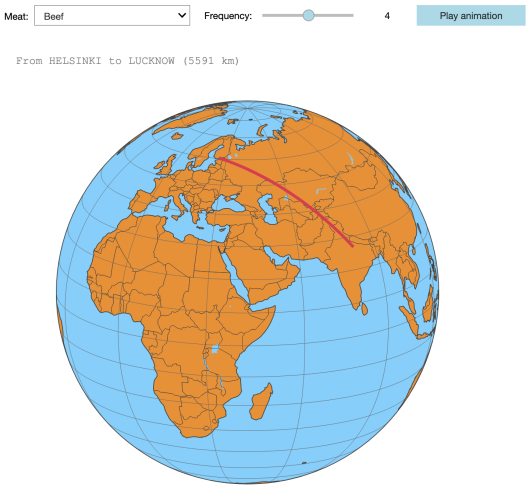
My second and main visualisation establishes a comparison between one's weekly meat consumption and the journey by plane that this consumption represents in terms of GHG emissions. Figure 2 illustrates the visualisation for the four types of meat considered in this project - namely beef, lamb, pork and chicken. Let's go into a little more detail to fully understand the comparison behind this visualisation.

Initially, the user running the visualisation faces a world map in 3D that he/she can rotate using the mouse. Above the globe lie one drop-down menu that allows the user to select the type of meat he/she usually consumes (between beef, lamb, pork and chicken), and a slider allowing him/her to specify how often this type of meat is consumed *a week* (number ranging from 1 to 7). Once the user has mentioned these two aspects, the visualisation will automatically (no clicking required) finds a flight journey which is equivalent in terms of GHG emissions to *one year* (52 weeks) of consumption of the mentioned meat at the specified frequency. For example, Figure (2a) actually tells the user that eating beef four times a week for one year is equivalent to taking a flight from Helsinki (Finland) to Lucknow (India), corresponding to a journey by plane of 5591 kilometers. This journey automatically appears as red line on the map as soon as a selection is made with the drop-down menu and slider.

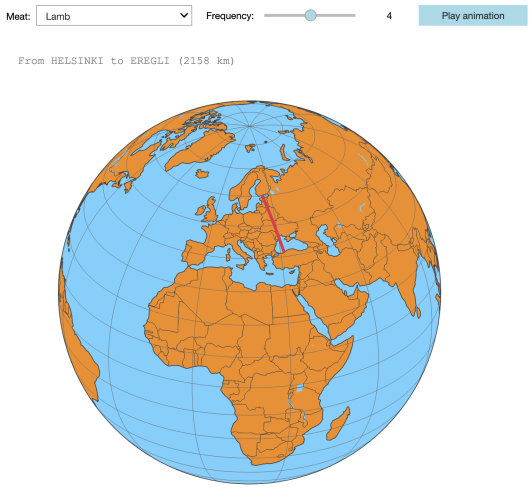
Once the flight journey as appeared on the world map, the user can click the "Play animation" button

in the top right. Figure 3 illustrates what happens when this button is clicked. It basically simulates the flight that previously appeared as a red line by showing a red dot (playing the role of the plane) moving from origin to destination. The full journey is divided in 52 displacements of same distance, and the point is moving every second performing one of these displacements until it reaches destination. Each move actually corresponds to one week of the selected diet, and allows the user to become aware of the exact number of kilograms of CO_2 emitted if he/she follows that diet. For example, Figure (3c) is captured after 36 moves of the red dot (after 36 seconds) from Helsinki and is telling the user that if he/she is eating beef seven times a week, then after 36 weeks he/she would be responsible for emitting 781 kg of CO_2 in the atmosphere, which comes down to flying 6797 km by plane (on the road from Helsinki to Celaya).

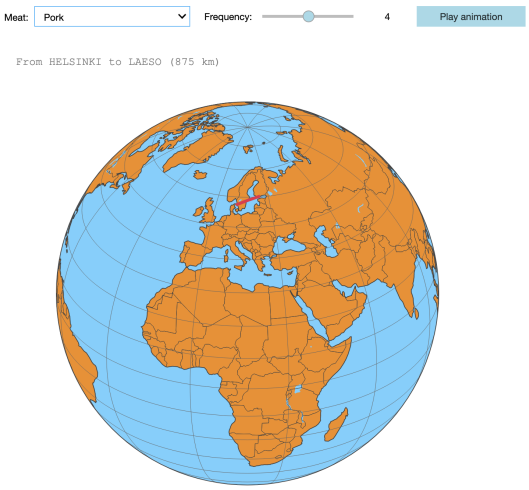
A demo of this visualisation is available here. Also, one can play with the visualisation by running this Jupyter Notebook.



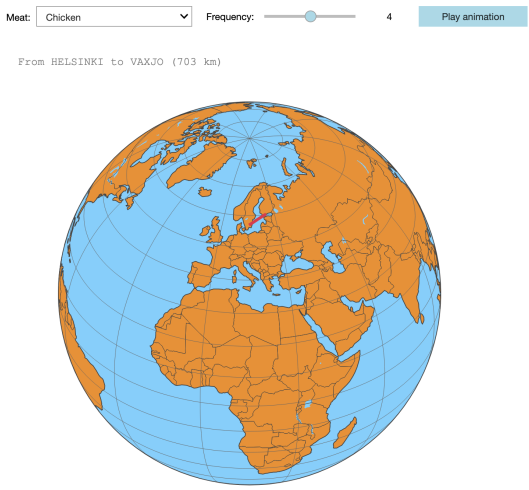
(a) Eating beef 4 times a week during a year



(b) Eating lamb 4 times a week during a year



(c) Eating pork 4 times a week during a year



(d) Eating chicken 4 times a week during a year

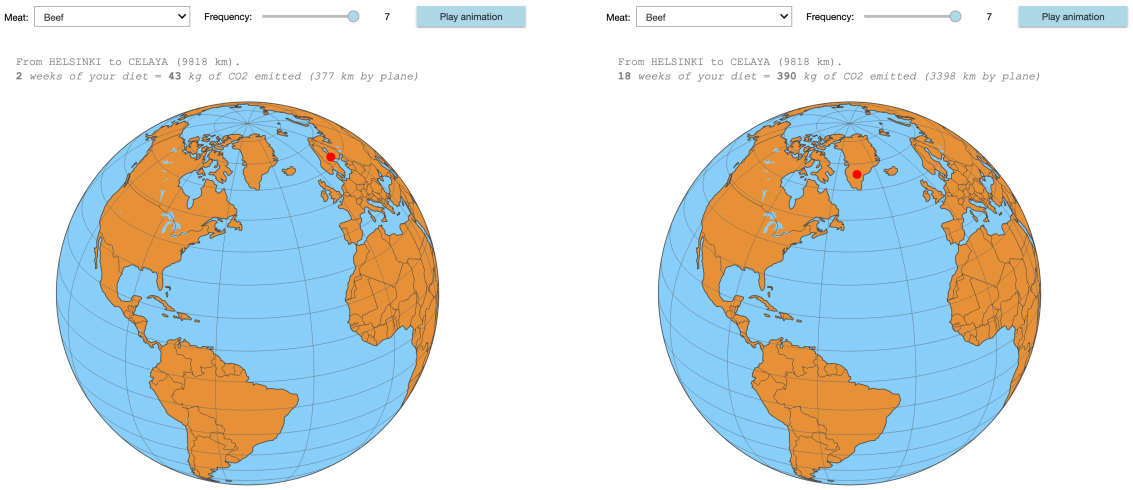
Figure 2: Comparison of the consumption of the four types of meat in terms of equivalent flight journey.

3.2.2 How it works

This section briefly describes the journey selection mechanism behind the visualisation. When the user makes his/her selection, a program automatically computes the amount of CO_2 emitted a year that it represents, thanks to the conclusions from [1] and the hypotheses of [3]. Given that number, it then calculates the equivalent number of kilometers by plane using the hypothesis from [4]. Finally, it randomly

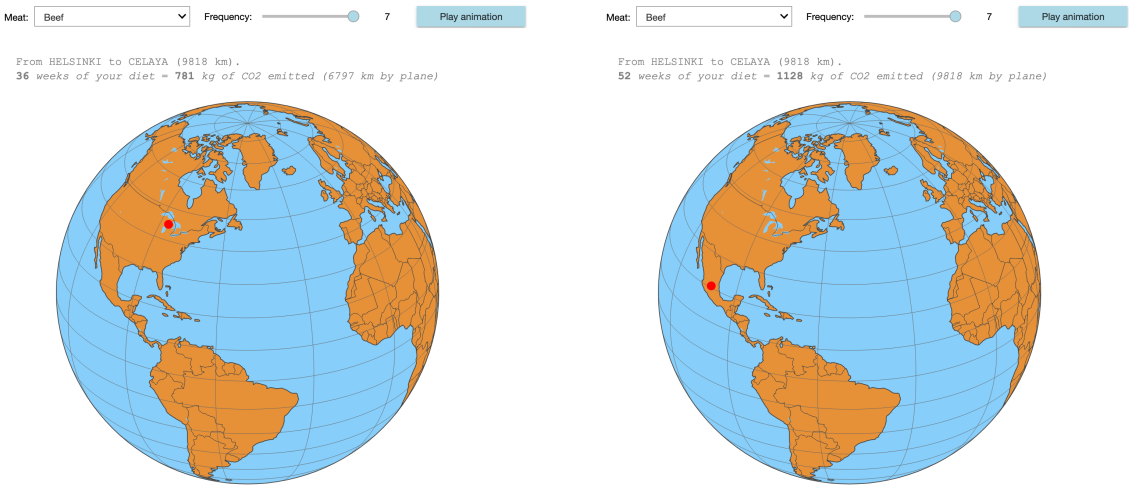
selects a destination for which the distance between Helsinki (for now, the origin is always Helsinki) and that end-point is approximately equal to the computed number of kilometers (with a tolerance of 50 km). This random selection is made possible by the *Global Airport Dataset* [2], for which an additional feature has been computed for each airport of the data set, which is the distance from that airport to Helsinki airport.

This randomness in the selection of the journey was implemented in order to make the visualisation more "playable", in a sense where the human being often loses interest if he knows what is going to happen when he undertakes an action. Here, after having fully understood the visualisation by playing a bit with it, the user will still be interested in testing it more thoroughly because he/she will be intrigued to discover which destinations do a particular diet correspond to, as these destinations will change each time.



(a) After 2 weeks

(b) After 18 weeks



(c) After 36 weeks

(d) After 52 weeks

Figure 3: Playing the animation for the diet "Eating beef 7 times a week for one year"

3.2.3 Space integration

The integration of space is pretty obvious in this visualisation, as the 3D world map is the main feature in it. As mentioned in the beginning of the report, I wanted to integrate objects and/or actions that everyone can relate to. Here, the object is the 3D world map and the action is taking a plane.

In my opinion, having the world map in 3 dimensions is more meaningful than having it in 2D, as it represents our planet as it really is. On the contrary, a 2D world map involves a transformation from a

3D globe to a 2D map which often leads to some distance inconsistencies and thus does not fully reflect reality.

3.2.4 Time integration

The integration of time is a bit more subtle. It comes into play as soon as the user launches the animation thanks to the "Play animation" button. It actually works as a clock, counting from 0 to 52, where each second represents at the same time one week of the selected diet, but also a displacement of 1/52 of the total equivalent journey (in terms of GHG emissions) by plane.

At each move of the red dot (plane), the message *"`nb_weeks` week(s) of your diet = `nb_kilo` kg of CO_2 emitted"* is updated, where `nb_weeks` indicates the number of weeks during which the selected diet has been consumed (current value of the counter from 0 to 52), and `nb_kilo` tells the amount of CO_2 emitted that it represents.

4 Conclusion

4.1 Expectations and results

The intended purpose behind the two visualisations presented in this report is to raise awareness about how significant consuming (red) meat is in terms of GHG emissions. I hope that the analogy with the flights by plane will make an impression and shock the users, so that they would seriously think about changing some of their eating habits and particularly reducing their meat consumption.

I must admit, however, that I was slightly disappointed with the end result of my second visualisation, as the comparison with the emissions of a plane might be tricky and not play in favour of the sought message. Indeed, some people might actually not be so astonished by the equivalent plane journey corresponding to the selected diet, as they might think that *"eating beef 7 times a week for one full year actually comes down to flying only once from Helsinki to Celaya"*, which might not be such a big deal for frequent travelers. Hence, my visualisation could also play completely against the desired message as people could think *"Why deprive yourself of eating meat when it comes down to only taking the plane once?"*.

Unfortunately, I became aware of this trickery once the visualisation was completely implemented. I honestly expected the numbers to be much larger when I first read the conclusions from [1], and that for example eating beef 7 times a week for one year would comes down to make four round trips from Helsinki to Tokyo, which in that case would be very surprising. After all, considering the plane for the analogy might not be the best tool to shock people as the CO_2 emissions of a plane are really huge. Anyway, this brief reflection got me thinking about alternatives and improvements that I could do in the future.

4.2 Future work

For now, playing with my visualisations requires the user to have Python installed on his/her machine as well as some extra libraries required for the Jupyter Notebook to run properly. In the future, I would like to integrate these visualisations into a website that everyone could access online from any machine without installing anything. The website will also be a way of giving a bit of context around the visualisations by introducing the problem and also providing solutions as a conclusion in order to make a difference. A first draft of this website has been implemented and the first visualisation has already been integrated. The draft is available here.

As mentioned in the previous section, I would like to illustrate the problem resulting from meat consumption with a variety of other visualisations, always with the intention of shocking the user with relevant comparisons with well-known objects and activities. In addition to GHG emissions, I would like to tackle the impacts on water consumption and deforestation as well, which are also truly significant according to [1]. With the same idea of creating analogies with objects and actions commonly known, here are some ideas that I have in mind concerning water consumption: *"Eating beef five times a week for one year requires as many liters of water as 15 Olympic swimming pools"* or *"Eating lamb two times a week comes down to take a shower of 4 hours"*. Concerning deforestation, one could think to the following comparisons: *"Eating one portion of beef three times a week for one year comes to use a land space equals*

to 20 soccer fields" or *"Eating lamb three times a week comes down to let the printer work continuously for 2 hours, and print a total of 3.500 sheets of paper".*

I really like these types of comparisons as it impacts a lot more the audience than just giving numbers. Here, a person that is a minimum concerned by the ecology would directly be shocked. In practice, I would just extend my current visualisation by keeping the selection of the consumed meat and its frequency of consumption, and add the new visualisations concerning water consumption and deforestation. To take back the example of the shower that is flushing, the visualization could simply be a 3D model of a shower flushing with a clock next to it that will count down from 4 hours to zero. This idea of 3D model plus clock counting down could also apply to the printer. For the soccer fields, the visualization could simply be a picture or 3D representation of a soccer fields that is progressively repeated by multiplying it by a factor x each second in order to finally obtain the desired number for the equivalence (same mechanism could be applied for the swimming pools).

References

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