Data Visualization Report

MEAT THE WORLD

A GLOBAL PERSPECTIVE ON MEAT CONSUMPTION AND ENVIROMENTAL IMPACTS

Laura Girometti 903221, Mariarosaria Altieri 901736, Chiara Pilone 898697

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1 Introduction

In this report, we will analyze the various stages of the design process for an infographic about *meat consumption and its environmental impact*. We will cover the selection of the topic and the target audience, the development of the data visualization design, the implementation and the evaluation of the final product.
The infographic can be viewed by clicking **here**.

Meat consumption has been increasing globally for several decades. According to the Food and Agriculture Organization of the United Nations (FAO), in the global average, per capita meat consumption increased by about 20 kg from 1961 to 2017. This trend is driven by a number of factors, including population growth, urbanization and rising incomes. In addition, the globalization of food systems has made meat more widely available and accessible.
Meat consumption patterns can vary significantly from country to country due to various factors, such as cultural traditions, religion, economic factors, and the availability of different types of meat in different regions. Some countries may have a strong tradition of consuming certain types of meat, such as beef in Argentina or pork in China, while others may have cultural or religious prohibitions against certain types of meat, such as Islam's prohibition on pork consumption.
Economic factors can also play a role, as some countries may have more resources to invest in livestock production and may therefore have higher levels of meat consumption. In addition, the availability of different types of meat may vary according to local climate, agricultural practices, and other factors that influence meat production and distribution.
Anyway meat is the go-to protein source for many individuals, with it occupying a favored position in many people's diets.
But *what is the environmental cost of the most loved food in the world?*
The production and consumption of meat have significant environmental impacts, including greenhouse gas emissions, land use and deforestation, and water use. These impacts can have serious consequences for the planet and its inhabitants. Greenhouse gas emissions from the livestock sector, which include methane produced by ruminant animals and carbon emissions from feed crops and transportation, account for approximately 14.5% of global emissions according to the Intergovernmental Panel on Climate Change (IPCC) [1]. The production of meat also requires large amounts of land for grazing and feed crop cultivation, which can lead to the conversion of natural habitats into agricultural land, including deforestation. In addition, the production of meat requires significant amounts of water for both the animals and irrigation of feed crops, which can result in overuse and depletion of water resources in some regions. The production of meat also has social and economic consequences, such as the displacement of

small-scale farmers and concentration of wealth and power in the meat industry.
In this infographic, we examine the trend of increasing meat consumption and its impact on the environment, particularly greenhouse gas emissions.
Through the use of interactive charts and graphs, we provide a comprehensive overview of the topic, including the consumption patterns of different types of meat and the environmental consequences of such consumption. By presenting this information in a clear and engaging way, our goal is to raise readers' awareness of the consequences of our meat consumption habits and to encourage them to consider more sustainable alternatives.
While meat is often a staple in many cultural diets, it is crucial to acknowledge the environmental impact of its production and consumption. It is necessary to explore ways to reduce the negative effects and strive for sustainable approaches to meat consumption. This does not necessarily mean completely removing it from our diet, but rather reducing consumption and incorporating more plant-based proteins into our meals. By doing so, we can work towards a more sustainable future.

2 Data visualization design

In this section, we will discuss the design of our data visualization dashboard and its main features. We will describe our goal in creating the dashboard, our target audience, and the datasets used to populate the visualization.

2.1 Goal

Our study aims to inform the public about the increasing trend of meat consumption globally and the negative environmental impacts associated with meat production. The infographic presents data on the growth of meat consumption over time, as well as information on the greenhouse gas emissions impacts of meat production. We will be able to answer to the following questions: *What has been the growth rate of meat consumption over time? Which countries have the highest consumption levels? How does consumption vary across different types of meat? How does the environmental impact of meat production compare to other types of food production? What is the production phase in which the most greenhouse gas emissions occur?*

2.2 Target

The target audience of the infographic is anyone who is interested in learning about the impact of meat consumption on the environment, as well as anyone who may be unaware of this issue but comes across the infographic by chance. The goal is to provide information and insights to help these individuals better understand the scale and consequences of meat consumption, and perhaps encourage them to consider their own consumption habits and the impact they may have on the environment. So, in general, it is for all those people who are open to learning about the reality of certain facts, even if they may be different from what they previously believed or their current habits. This infographic could also be targeted towards educators, policymakers, and organizations working to promote sustainability and environmental conservation, as it could provide them with valuable information and insights to help inform their work.

2.3 Dataset description

Two datasets were used to create the infographic: the first containing information regarding per capita meat consumption from 1961 to 2017, divided by type; the second regarding the environmental impact of food production. The data was obtained from the Food and Agriculture Organization of the United Nations (FAO) and was accessed through the Kaggle platform at the following links:

1. **Meat consumption per capita dataset**
2. **Environmental impact of food production dataset**

2.3.1 Meat consumption per capita dataset

This dataset contains records of per capita meat consumption by countries from 1961 to 2017. Per capita meat consumption refers to the average amount of meat consumed by individuals in a population over a given period of time, typically measured in kilograms per year.
The dataset includes 8 columns:

- *Country*,
- *Code*,
- *Year*,
- *Mutton and Goat* – Kg per year,
- *Poultry* – Kg per year,
- *Pig meat* – Kg per year,
- *Beef and buffalo* – kg per year.

Of course, the number of countries covered in the dataset reflects the geopolitical changes that have occurred over time. For instance, the USSR is part of the data until 1991, after which the states formed following its fragmentation (Russia, Ukraine, Armenia, Georgia, Kazakhstan, ...) are included.

2.3.2 Environmental impact of food production dataset

This dataset contains 43 common foods grown across the globe and 23 columns as their respective land, water usage and carbon footprints.
For our purpose we used a subset of the available data, selecting only 9 columns. These represent greenhouse gas (GHG) emissions expressed as kg of CO2 equivalents per kg of food product across different stages in the lifecycle of food production:

- *Food product*: food product name;
- *Land use change*: Kg CO2 – equivalents per kg product;
- *Animal Feed*: Kg CO2 – equivalents per kg product;
- *Farm (farm impacts in crop or livestock production including the manufacturing of inputs such as fertilizers, or emissions from manure)*: Kg CO2 – equivalents per kg product;
- *Processing (the conversion of raw ingredients into sold products, such as the processing of cereals into bread)*: Kg CO2 – equivalents per kg product;

- *Transport (this includes transport from the farm up to retail. Transport of food from retail to consumers' homes is not included)*: Kg CO2 – equivalents per kg product;

- *Packaging*: Kg CO2 – equivalents per kg product;

- *Retail (energy consumption in retail stores, such as refrigeration)*: Kg CO2 – equivalents per kg product;

- *Total emissions*: sum of Kg CO2 emissions resulting from the precedent columns.

Kg of CO2 equivalents is a unit of measure that considers all types of GHG using global warming potential (over 100-year timescale), a value which aims to represent the amount of warming that each specific gas generates relative to CO2. For example, 1kg of methane (CH4) corresponds to 28kg of CO2 (IPCC) in terms of global warming potential.
The values presented in the dataset are the global median values across the 38,700 commercially viable farms, in 119 countries.

3 Dashboard implementation

In this section, we will discuss the implementation of our data visualization dashboard, including the decision to use a long dashboard as the format, the considerations for accessibility and the choice of the colors used. In conclusion we will provide a description of the final visualizations.

3.1 Format choice

For this infographic, we have chosen to use a *long dashboard* because it is more effective in providing a general overview of the topic covered and allows us to logically link multiple data visualizations together.
Additionally, the long dashboard format is more practical and engaging for less experienced users, as it allows them to easily explore and understand the data at their own pace.
Overall, we believe that the long dashboard is the best format for presenting our data in a clear and accessible way.

3.2 Accessibility

In our infographic, we used a color palette that includes shades of *red, orange, pink*, and *brown* to evoke the image of meat and animals related to it.
The use of color is crucial in each part of the dashboard, as it helps to facilitate the interpretation of data and to draw the viewer's attention to key elements. For example, in the first chart, the intensity of the color represents the growth in meat consumption. In the following two charts and in the donut charts, the color identifies the category of membership.
For the *background*, we selected a neutral and warm color, a light creamy walnut. This creates a visually appealing and welcoming aesthetic for the viewers, and the warm color may subconsciously convey a sense of comfort and familiarity, which could help engaging the viewers, encouraging them to spend more time exploring the content of the infographic. Additionally, the use of this color as the background makes the content of the infographic more easily readable and accessible.
For the *lettering* and secondary elements, we used alternating shades of dark and light gray, avoiding the use of black due to its high contrast.
In selecting the colors for this infographic, we ensured that they would be easily distinguishable for those with color vision deficiencies. We used color simulators to confirm that the chosen shades would be clearly distinct in all cases.

Figure 1: Color palette 1

Figure 2: Protanopia

Figure 3: Deuteranopia

Figure 4: Tritanopia

Figure 5: Color palette 2

Figure 6: Protanopia

Figure 7: Deuteranopia

Figure 8: Tritanopia

3.3 Description of data visualizations

Our final infographic is the result of the following data visualizations.

3.3.1 Circular bar chart

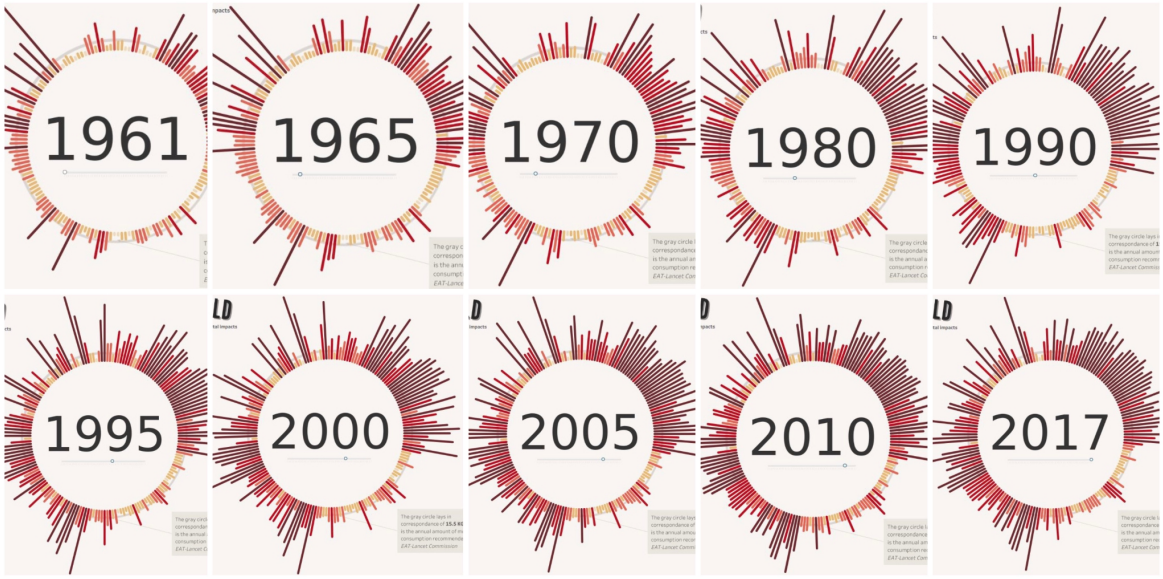

Figure 9: Circular bar chart

As our first visualization, we chose an interactive circular bar graph representing the distribution of meat consumption per capita in different countries through the use of a relationship one (data attribute - *total amount of meat consumption*) to many (graphical attributes - *length* and *value*). Each bar represents the sum of the four types of meat in a given country in one year and it becomes longer and darker as meat consumption increases. As a reference point, to make the representation clearer, we placed a gray circle in correspondence of 15.5 kg, that is the annual amount of meat consumption recommended by EAT-Lancet Commission. [1]

The purpose of this infographic is to create a shocking first impact that makes the viewer think about the magnitude of the phenomenon of increasing meat consumption. By presenting the data in a visually appealing way, we hope to draw the viewers' attention to the problem and encourage them to consider the implications of this trend.

The use of polar coordinates in this infographic also allows us to represent a large number of bars in a more limited space, making it easier for the viewers to see and understand the data at a glance. This is particularly useful when compared to a horizontal arrangement, which could potentially result in the information being lost or difficult to interpret as a whole.

[1] https://eatforum.org/lancet-commission/eatinghealthyandsustainable/

3.3.2 Line chart

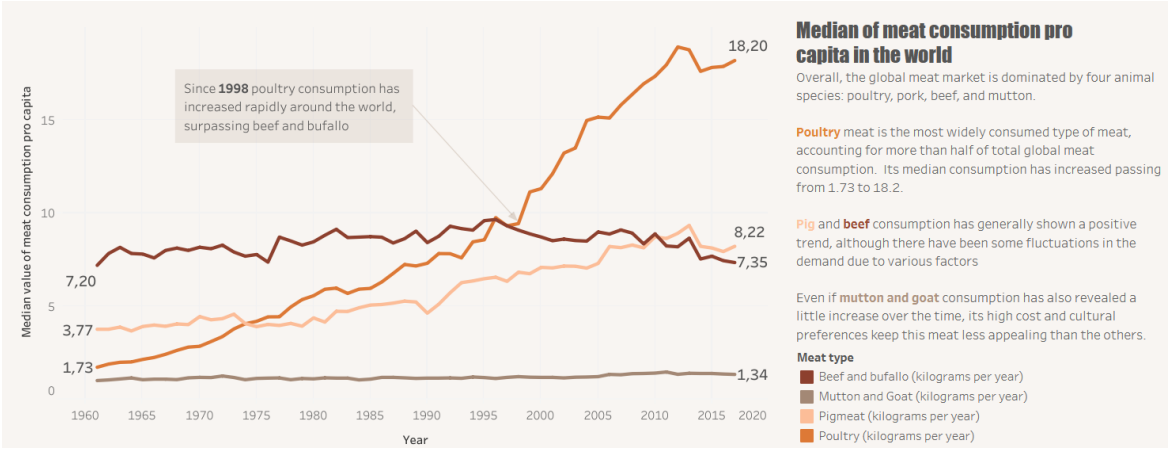

Figure 10: Line chart

After providing an overview of the amount of meat consumed in the world over the past 60 years, in this data viz we want to illustrate what is the trend over time of the median consumption pro capita for each type of meat from 1961 to 2017.
We have used the median because, differently from the mean, it is a robust measure and therefore is not affected by possible outliers in the distribution.
We know that the best way to visualize the trend of a phenomenon is to use a line graph, because it allows the viewer to easily see how the data has changed over a period of time.
The visualization depicts 4 lines one for each type of meat: poultry, beef, pig and mutton.
There are two aspects that we can immediately spot: an exponential growth in the consumption of poultry and a very low consumption of mutton and goat.
In fact, we note how the median consumption of poultry per capita has increased from 1.73 to 18.2 (it would be interesting to see which countries eat more poultry, but we will come back to this point later). However, at a glance we can see that until 1998 there was an almost constant growth in its consumption, while afterwards the consumption started to increase rapidly, surpassing the beef one. There are several reasons why poultry consumption has increased rapidly around the world, especially since 1998. One reason is that poultry is a relatively inexpensive source of protein compared to other animal meats, making it more accessible to a larger portion of the population. Additionally, it is generally easier to produce and requires less land and resources to raise compared to other livestock, making it more sustainable and environmentally friendly. Poultry is also perceived as being a healthier option compared to red meat, which has contributed to its increasing popularity. Finally, advances in technology and transportation have made it easier to produce and distribute this type of meat on a large scale, further increasing its availability and affordability.

Regarding the consumption of mutton this meat is generally considered to be less tender and flavorful compared to other meats, which may make it less appealing to some people. Additionally, mutton and goat production tends to be more labor-intensive and resource-intensive compared to other types of livestock, which can make it more expensive to produce and therefore less affordable for consumers. Moreover, cultural and dietary preferences also play a role in determining the popularity of different types of meat, and in some parts of the world, mutton and goat meat is simply not as commonly consumed as other types.
Finally, we can see that pig and beef consumption has generally been on the rise around the world, although there have been some fluctuations in demand due to various factors such as economic conditions, health concerns, and cultural and dietary preferences.

3.3.3 Bubble map chart and race bar chart

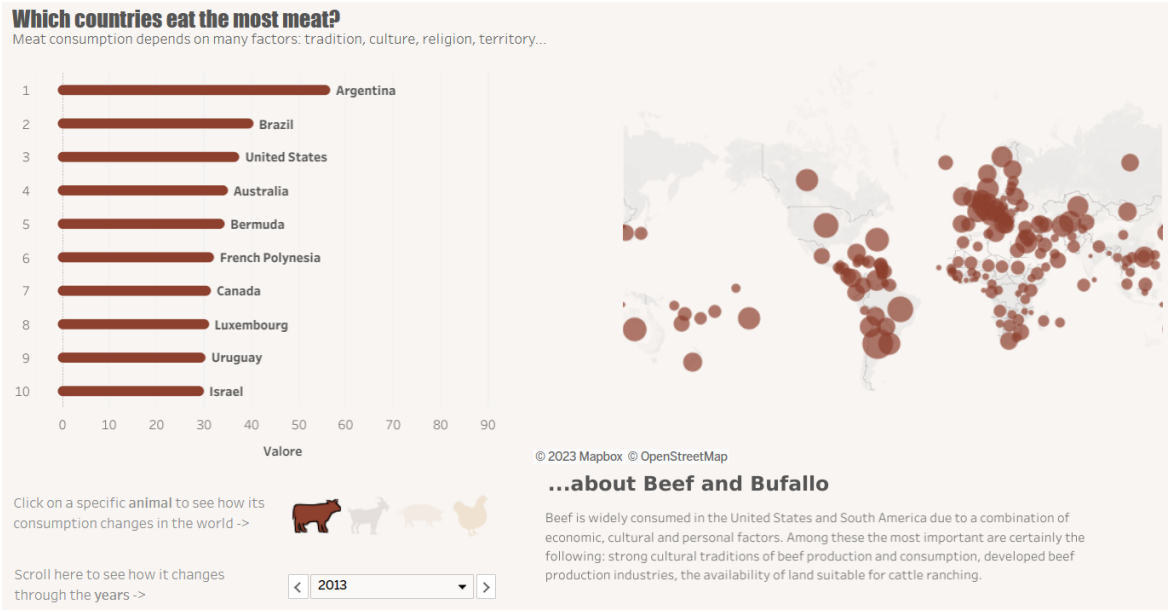

Figure 11: Bubble map chart and race bar chart

Let's now go and see in detail how the consumption of the different types of meat has changed in the various territories over the years. To do this, we used a race bar chart connected to a bubble map chart in which, through the size of the bubbles, we note the amount of meat consumed in the different states.
This is one of the most interactive data viz of our dashboard, because we find both the filter to select the type of meat and the one to scroll through the years. The race bar chart shows the ten countries with the highest consumption for a particular type of meat and are arranged in descending order. In fact, we can see how the states change according to the type of meat and also according to the year.
The visualization confirms the low diffusion of mutton and goat meat shown previously in the line graph, but it is interesting to understand why over the years the country

with the highest consumption of this type of meat has been Mongolia. One of the main reasons is that mutton and goats are well-suited to the harsh and arid climate of Mongolia, where they can survive on low-quality forage and rough terrain.
Cultural and dietary preferences also play a role in the popularity of these meats in Mongolia. Mutton and goat are an important part of the traditional Mongolian diet, and their consumption is closely tied to cultural and religious practices.
Another interesting thing that we can spot is that Argentina is one of the top beef-consuming countries in the world. In fact, Argentina has a long history of cattle ranching, and the country is known for producing high-quality beef from grass-fed cows. The favorable climate and fertile grasslands of Argentina provide ideal conditions for raising cattle. Beef is also a staple food in Argentina, and it is traditionally served as a main course at most meals.
You can have fun changing the different filters and discover many other interesting things, like these just seen above, which perhaps without this data viz you would never have noticed.

3.3.4 Dendrogram chart and donuts charts

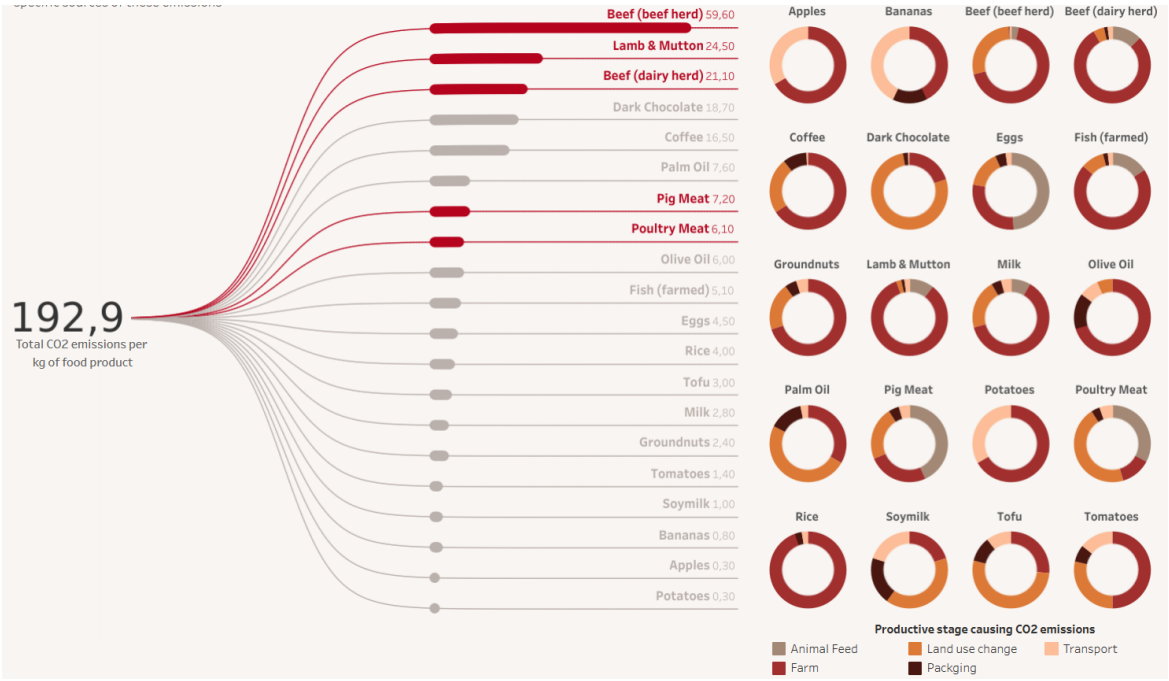

Figure 12: Dendrogram and donuts chart

The main objective of this data visualization is to assess the relative climate impact of different food groups, focusing on how gas emissions from meat, diary and other diets compare. More specifically, 20 products commonly eaten all over the world are considered in order to see which ones have the most dangerous impact on the environment.

The dendrogram on the left illustrates the greenhouse gas emissions produced per kilogram of different food products. This analysis considers all the different factors that go into producing food, including animal feeding, the land required for production, the farming process and the transportation and packaging stages. The considered dataset contained also information about the emissions derived from the processing and retail stages; however, they are not considered in the calculation of the total amount of CO2 produced, since their environmental impact has proved to be less significant.
The resulting dendrogram clearly shows how animal-based foods (which are highlighted in red) tend to have a larger carbon footprint, occupying the first positions. In particular, the climate impact of beef and lamb dwarfs that of other foods. This is partly due to the biology of how these animals digest food: cows and sheep belong in fact to the category of "ruminants" – meaning that their stomachs contain specialized bacteria capable of digesting tough and fibrous material, such as grass. The digestive process causes the animals to belch out methane, greenhouse gas that is around 28-34 times more powerful than CO2 over a period of 100 years. Pig and poultry meat, while having a greater impact on the environment if compared to those of plant-based food, result to be a more climate-friendly choice to the red meat option.
The chart illustrates that the rearing of a beef herd pollutes more than twice as much as a lamb, about 10 times as much as the production of oil and 22 times as much as the production of milk, thus having a strong impact on the environment, that can no longer be underrated.
On the opposite, as we could expect, all plant-based food, like apples, bananas, tomatoes and potatoes have a very low carbon footprint, placing themselves at the last positions of the dendrogram.
Interesting exceptions to the above consideration are represented by two products, which are coffee and chocolate. Coffee is mostly grown in tropical regions and, for its production, high amounts of nitrogen fertilizer are required. This explains the reason behind its large climate impact by kilogram compared to the one of other plant-based foods. On the other side, chocolate's environmental impact is mostly due to the land-use change required to produce cocoa (77.3%).
This information about the origin of emissions can be seen in the donut chart associated with each food category: each product depicted in the dendrogram is indeed associated with a donut chart (that highlights when passing the mouse over a specific food) on the right side on the screen, which allows us to go into a deeper level of detail, understanding what are the specific stages of the supply chain that can be identified as the cause of the reported level of emissions.
If we focus our attention on the two most polluting food -beef and lamb- we can see how the main source of CO2 emissions is the farming stage, that accounts respectively for the 67.8% and 84.1% of the total gas production. This particular stage of the supply chain turns out to be the principal cause for greenhouse gas emissions also for

non animal-based food, like groundnuts, olive oil and rice. Regarding the latter, more than the 90% of emissions are produced during farming phase.
Moreover, grazing animals require a lot of land, which is often cleared through the felling of forests, as well as vast tracts of additional land to grow their feed. With a rise in the eating of beef in large countries that have witnessed increasing prosperity, such as China, cattle farming has become extremely lucrative. In pursuit of profits, ranchers have destroyed hundreds of thousands of square miles of rainforest around the world—vital, biodiverse ecosystems that, when undisturbed, capture millions of tons of CO2.
The donut charts also give us the possibility to answer a common question that may probably arise at this point of the analysis: is it better to eat local food? It is a typical belief that "local meat" has not had to travel by plane or ship before it arrives on the plate and, therefore, must be more environmentally friendly than other foods from further away. However, an interesting thing that emerges, is that transport is just a small contributor to emissions. For most food products, it accounts for less than 15%, and it's much smaller for the largest GHG emitters: indeed in beef from beef herds, it's 0.6%. Since transport only accounts for a small proportion of food's average emissions, it is clear that choosing to eat local has very minimal effects on its total footprint.
In conclusion, the proposed data visualization highlights the responsibility of meat industry in global greenhouse gas emissions. It contributes not only to global warming, but also causes a direct environmental pollution.
So, *what can we do in a concrete way, in order to reduce this preoccupying phenomenon?*
People who eat a lot of meat can help in fighting the climate crisis, by quitting or simply reducing the total amount of meat they consume; also a mere substitution of beef meat with other types of animal-derived food, like poultry of pig, could lead to a considerable reduction of greenhouse gas emissions. In fact, as said by Alexandre Koberle, research fellow at the Faculty of Natural Sciences at The Grantham Institute for Climate Change: *"Next to flying less, it is probably right to say that, as individuals, reducing beef consumption is the most significant contribution directly under our control"*.

4 Evaluation

In this section, we describe the various steps we took to *evaluate* the effectiveness and accessibility of our dashboard. To begin with, we employed heuristic evaluation as a way to identify areas for improvement. This is a formative method, since it is conducted during the development phase, and it allows for iterative changes to be made to the dashboard, ensuring that it is as effective as possible. Then, to guarantee that our infographic was effective in conveying information and easy to use, we conducted evaluations with users to assess its accessibility and usability. Finally, we administered a psychometric questionnaire to gauge the perceived value of the infographic to the users.

4.1 Heuristic Evaluation

Heuristic evaluation is a method of evaluating the usability and effectiveness of a user interface, including data visualization dashboards, by examining the interface against a set of established usability principles or heuristics. These heuristics provide a set of guidelines that designers can use to ensure that an interface is easy to use, efficient, and effective for its intended audience.
In this section, we will describe the heuristic evaluation process that we followed for the evaluation our data visualization dashboard. By applying these heuristics, we aimed to identify any usability issues with the dashboard and to provide recommendations for improving the user experience.
Heuristic evaluation is particularly important in the context of data visualization, as effective data visualization is essential for helping users understand and make sense of complex data sets. By conducting a heuristic evaluation, we can help ensure that our dashboard is as useful and effective as possible for our audience.
We asked 3 experienced users in the field of data visualization - whom we will call User 1, User 2, and User 3 for convenience - to explore our dashboard by commenting aloud on their actions and thoughts.
Overall, the data visualization dashboard received positive feedbacks from users. In particular, the use of an original graphic as the first visualization, followed by a more familiar graphic that made the concept clearer, was highly appreciated.
However, some issues were identified during the heuristic evaluation.
The use of colors in the original choropletic map to distinguish meat consumption by state was found to be confusing and overwhelming by all users. The visualization resulted in an excessive amount of information that is redundant to the race bar chart. The colors were also uniform and difficult to distinguish between different countries, making it challenging to perceive small variations in consumption: in fact, in some cases, the highest consumption was associated with small states, making them difficult to identify while homogenizing the others. This made it difficult to detect areas

of higher or lower consumption, resulting in users only being able to discern stark differences.
Moreover, User 1 suggested adding annotations to the first two graphs to clarify the extent of the increase in meat consumption. User 2 found the drop-down menu in the choropletic map to change the year not very intuitive. Finally, User 3 had difficulty distinguishing the colors of the "Farm" and "Packaging" fields in the donut charts, as they were too similar.
As a result of these considerations, we made several changes to the data visualization dashboard to improve understanding and usability.
First of all, we made the decision to replace the choropletic map with a bubble map chart. This change allowed us to more clearly identify areas with higher or lower levels of meat consumption at a glance (regardless the State size), highlighting differences between states and continents more effectively. In fact, determining color ranges with a logical and comprehensive approach to represent the various differences proved to be a challenging task and we found that the use of areas was a successful solution for addressing this issue. Additionally, the use of a single color in the bubble map chart helped to create a more cohesive and harmonious overall appearance for the dashboard.

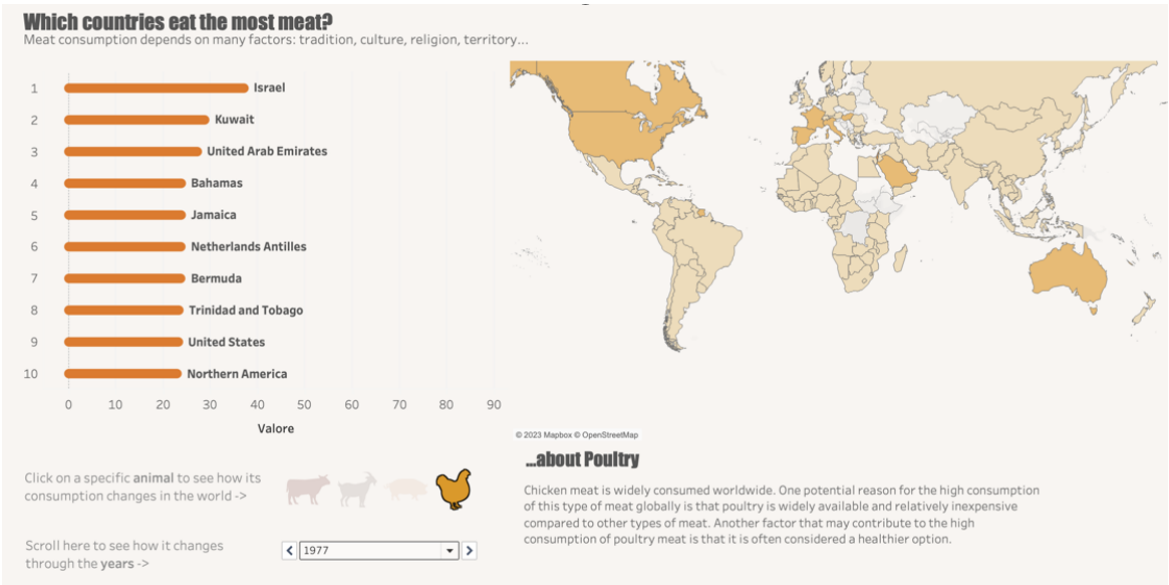

Figure 13: Choropletic map before heuristic evaluation

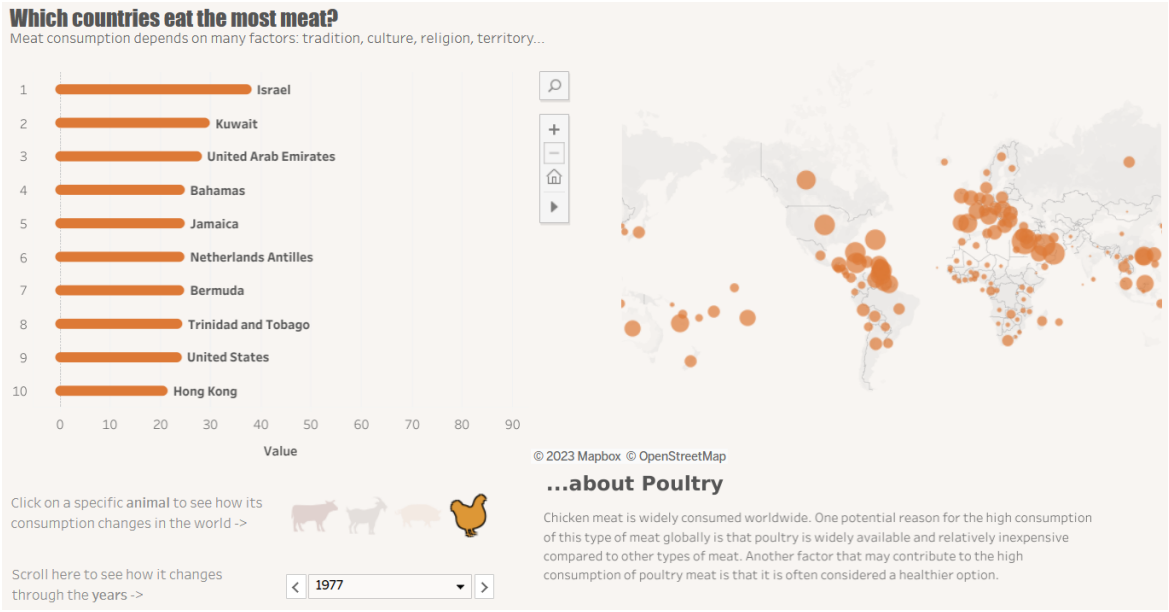

Figure 14: Bubble map chart after heuristic evaluation

To address the issue raised by user 3, we added a more informative caption near the drop-down menu to guide the action of the viewers.

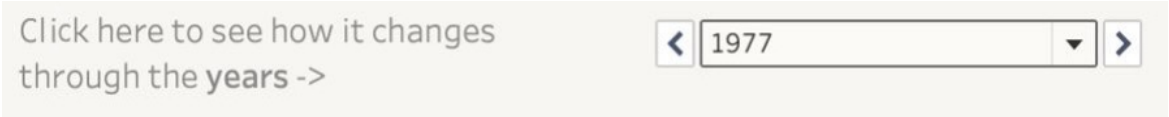

Figure 15: Caption of drop-down menu after heuristic evaluation

According to the suggestion of user 1, we added a gray circle to the circular bar graph to highlight the annual amount of meat consumption recommended by the EAT-Lancet Commission. This helps viewers to better understand the significant increase in meat consumption.

Figure 16: Circular bar graph before heuristic evaluation

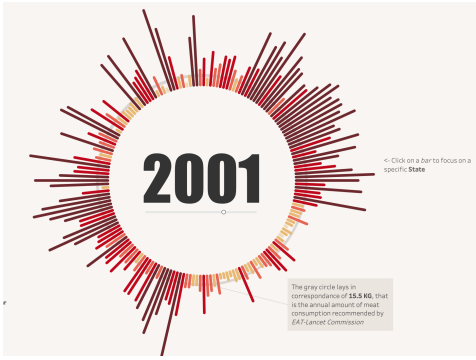

Figure 17: Circular bar graph after heuristic evaluation

Additionally, we included the starting and ending values in the line chart to make the median value increase over time more clear.

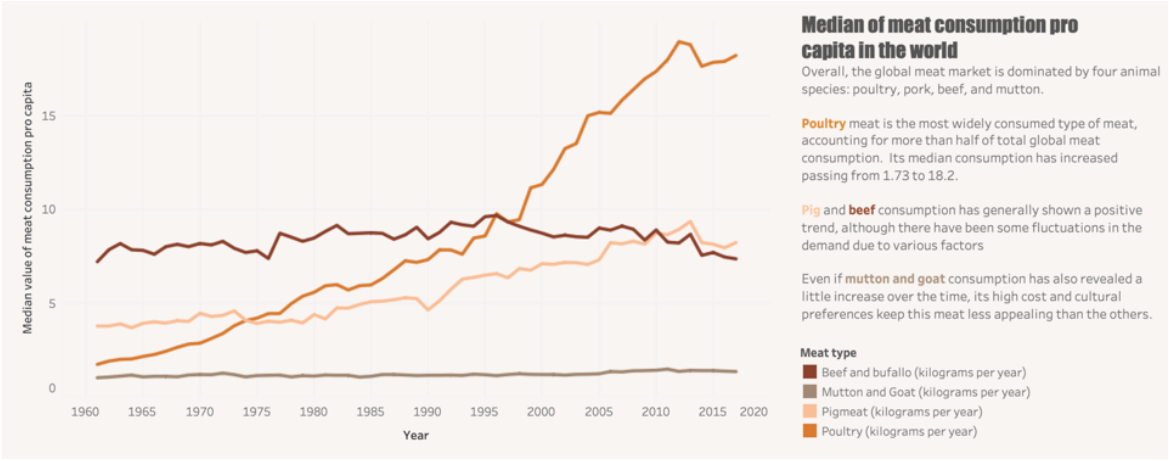

Figure 18: Line chart before heuristic evaluation

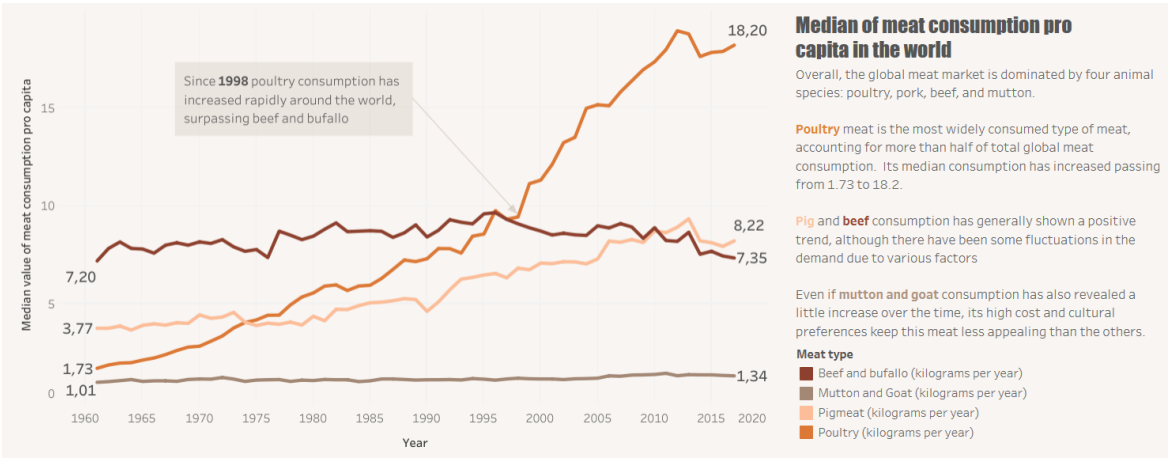

Figure 19: Line chart after heuristic evaluation

As a final change, we modified the color of the "Farm" category to a lighter shade to better differentiate it from the "Packaging" stage.

Figure 20: Color of Farm and Packaging before heuristic evaluation

Figure 21: Color of Farm and Packaging after heuristic evaluation

4.2 User test

Since the main objective of our project is to deliver our message to a variegated audience in an effective and impacting way, we also decided to conduct a User test which would allow us to collect valuable insights in order to create an even-better user experience.

The high density of information as well as the elevated degree of interactivity which characterizes the developed dashboard, made the user test an inevitable step for the purpose of evaluating our work and looking for opportunities of improvement.

Here we report and briefly summarize the three main steps which we have followed in order to carry out the user test:

1. **Define the goals of the user test**. *What do you hope to learn from the study?* The main objective of this test, as mentioned above, is assessing the effectiveness of the visualization in communicating the data, as well as determining the level of usability of the infographic, aiming at finding an overall ease of use.

2. **Identify the participants for the user test**. *Who will you be testing the visualization with?* For this user test, we gathered a group of 13 neutral and unbiased participants, accurately chosen in order to select a representative sample of the target audience for the visualization. Keeping in mind this aspect, we mixed people of different ages and having a different level of expertise, so to help us understand how the visualization performs for different groups. Those people will be then asked to interact with the data visualization performing some tasks.

3. **Prepare the tasks and conduct the test**. *What will be people be asked to do?* For each visualization included in the infographic, we designed 2 different tasks that people will be asked to perform. For each of them, it will be recorded and analyzed:

    - The level of expertise of the individual (expert/non expert) and his age,
    - The time required to perform the task,
    - If the task was successful or not,
    - The number of errors

4.2.1 Tasks

Now we describe, for each visualization, which are the tasks that we asked the participants of the test to perform:

Data viz	Task	Description
Circular bar chart	Task 1	Select and view randomly the annual pro-capita kg of meat consumed by a state in 2001
	Task 2	Individuate the trend of meat consumption worldwide: has it increased or not?
Line plot	Task 3	State the year starting from which poultry consumption surpassed beef consumption
	Task 4	Individuate in 1975, how many kg of mutton and goat meat were consumed by an individual?
Bubble map and race chart	Task 5	Find which State ranked as the most consuming of pig meat in 2010
	Task 6	Find which State ranked as the third principal consumer of beef and buffalo meat in 1989
Dendrogram and donuts chart	Task 7	State which is the principal source of pollution deriving from the production of 1kg of beef
	Task 8	In the production of 1kg of poultry meat, which is the percentage of emissions due to the transport phase?

4.2.2 Users analysis

The users' age and their level over expertise are the characteristics that are stored in order to realize further analysis aiming at comparing the different strata of our sample; more specifically, we are interested in discovering whether expert people find the data visualizations more easy to use than non-expert people do. The same comparison will be performed among people belonging to 3 different age groups (18-30, 31-45, 45+). We decided to not consider the sex of the individual (Male/Female), since we don't think that, considered this specific topic, there may be any particular difference in the way the work is perceived by both genders.

In the selected group of users, the majority is classified as a non-expert in the data visualization field (77%); This seemed a good option, due to the fact that the infographic could be directed to a variegated audience, and not only to experts of this sector. For this reason, feedbacks and comments from those users may provide useful insights in order to understand the usability of the infographic itself.

As regards the age, almost a half of the sample belongs to the younger people group. Then, the middle-aged and senior groups account respectively for the 30.8%

and 23.1% of the total.

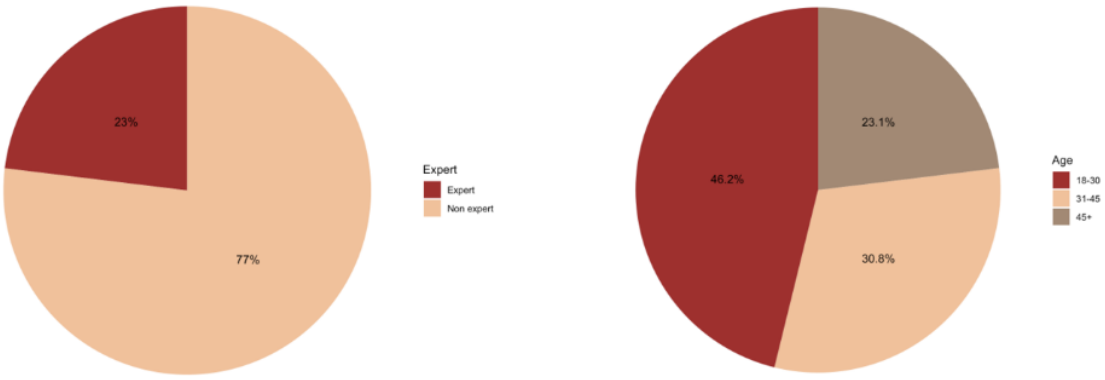

Figure 22: Pie chart for expert and age

4.2.3 Time of execution

We can now shift the attention towards the time of execution (expressed in seconds) required by each of the 13 component of the sample to perform the tasks.

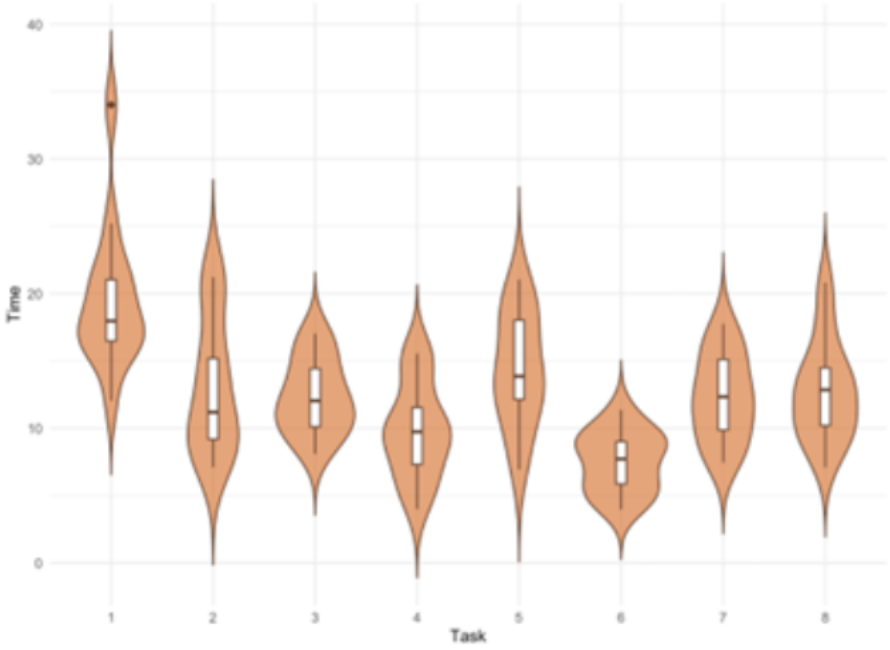

Figure 23: Violin plot for time of execution

Many useful considerations may be made starting from the observation and the analysis of the violin plots (Figure 23) associated with each task. First of all, it seems that the first task – despite being quite easy in terms of number of manual steps to perform in order to be completed – is the most time-requiring one. This is probably due to the fact that users have their very first approach with the infographic: some time will be therefore needed in order to become sufficiently familiar with it.

Another interesting aspect emerging from the above plot, is that – since 2 tasks have been conceived for each of the 4 data visualizations – the second task is always performed in less time compared to the first one: the violin plot – and the inner boxplots – associated with even number task (and so, with the second task of the same visualization) are always lower than those relative to odd number task. This is partially connected to the concept of familiarity that we have just mentioned. After having had a first-approach with the graphic, accomplishing the second assignment will be easier and quicker.

An exception to the above consideration is made by the last data visualization; indeed in this case, the median of the time needed for the last task is slightly higher than the one required for the previous assignment. However, this can be probably justified by the fact that, after having interacted a lot with the infographic, people started getting tired and so they took longer to go further.

4.2.4 The impact of Expertise

In order to see if the fact that a user is an expert in data visualization influences the time of execution of a task , we decided first of all to perform a statistical test: the *t-test*. This test will in fact help us to determine if the mean time of execution of a task is significantly different between the two groups of users (experts and non-experts).

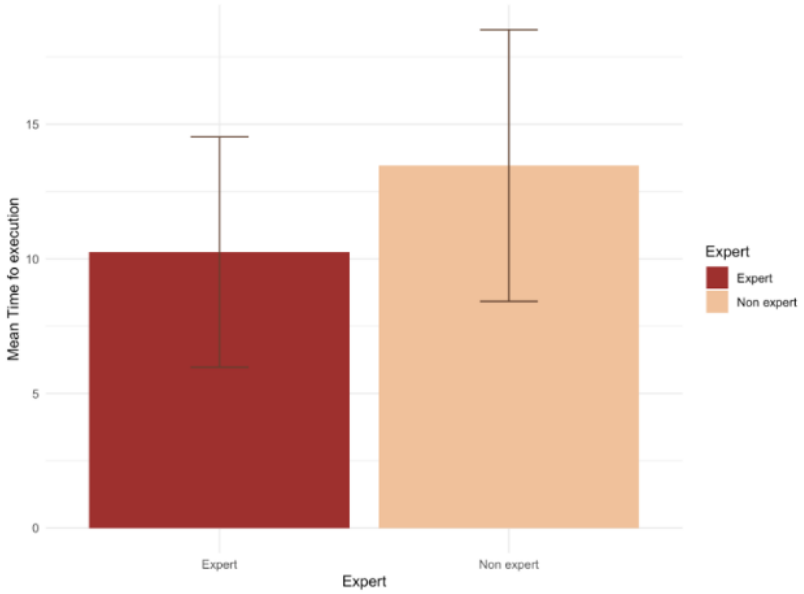

Figure 24: Bar-plot with IC of the distribution of time for expert and non-expert group

In order to carry out the *t-test*, we calculate the mean time of execution (also reported in the bar plot with error bars above) and the standard deviation for each group; then we use the *t-test* to compare the 2 means and determine if the difference is significant or not. The p-value resulting is equal to 0.03; since it is lower than the pre-specified significance level (we opted for alpha=0.05), we can conclude that there

is a significant difference between the means of the two groups: in other terms, the fact that a user is an expert influences the time of execution of a task.

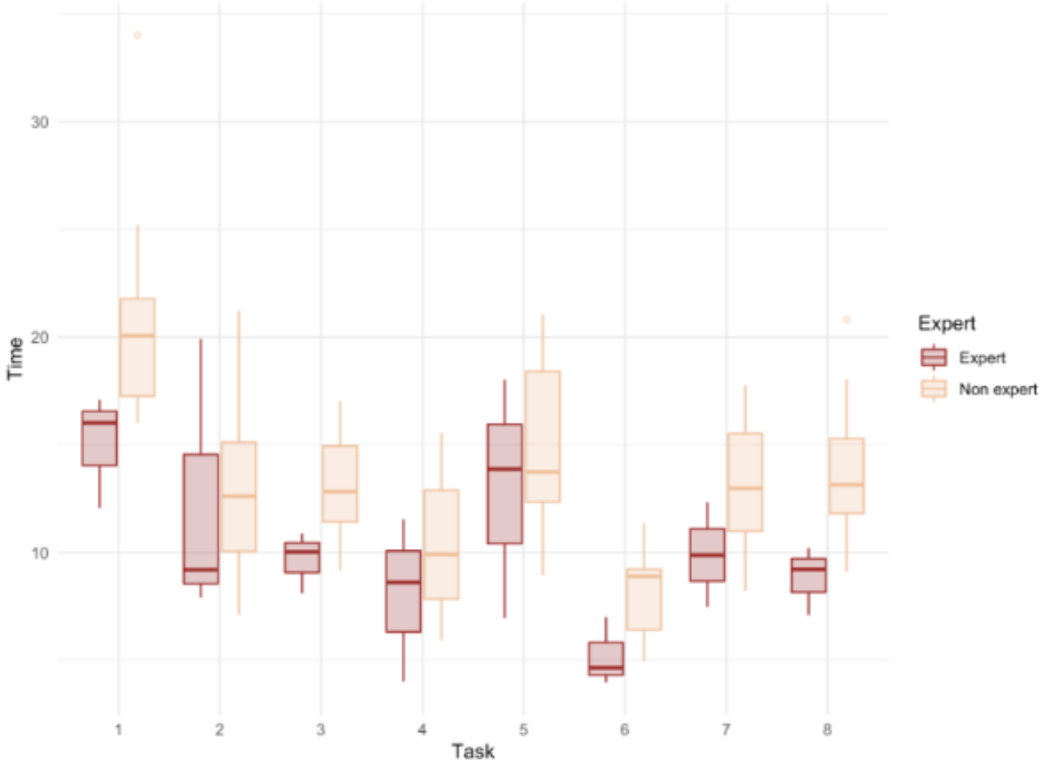

Figure 25: Boxplots of the distribution of time for expert and non-expert group

The above chart (Figure 25) plots the distribution of the variable "Time" for the 2 groups. We can notice without any surprise that, for each of the 8 performed task, the IQR of the Expert group is lower than the one of the non-expert.

4.2.5 The impact of Age

At this point we ask ourselves if also the age has a significant impact in determining the usability of the infographic. We repeated the same steps described above, but taking this time into consideration the variable "Age". However, the *t-test* resulted in a p-value higher than the pre-specified significance level 0.05, letting us arrive to the conclusion that being younger or elder has no significant effect on the time required to perform the assignments.

4.2.6 Conclusions

Finallly, the user test we have carried out has brought out to positive conclusions; in particular, the absence of errors – and so, the fact that each user has managed to solve the given task without any need for help – makes us belief quite firmly in the overall efficacy of the infographic; the messages that we wanted to transmit through our work, seem to reach appropriately the audience of any different age.

As it may be expected, better performances in terms of time were achieved by expert users, but despite that, the results of the user test are generally satisfactory and the infographic appears to be efficient in terms of time required to perform the prepared tasks.

4.3 Psychometric Questionnaire

We have also used the psychometric questionnaire to evaluate the performance of our infographic, because we know that this method is useful to discover where people find our work better. We administered the questionnaire to 24 students, in order to obtain statistically significant results. We used the *Cabitza Locoro scale* [2], which allows the evaluation of the quality of the infographic on a scale from 1 (very low) to 6 (very high) for the following fields:

- Utility
- Clarity
- Informativeness
- Beauty
- Intuitiveness

Finally, it requires attributing an overall value to the infographic. The aim is to assess what is the value perceived by users about our data visualizations.

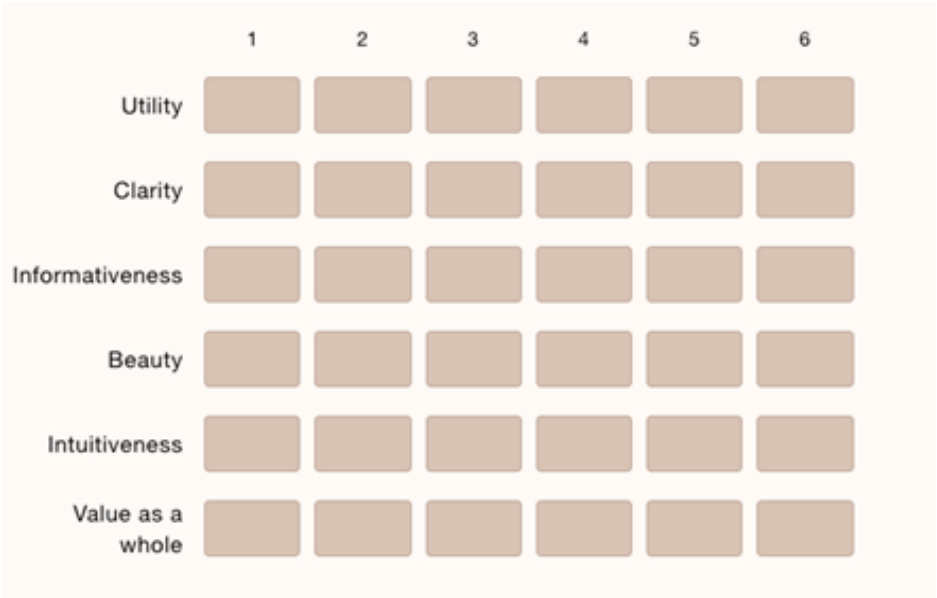

Figure 26: Structure of the survey

Let's see the results . To see in detail how many people attributed a certain value to that category, we used the bar plot showed in Figure 27.

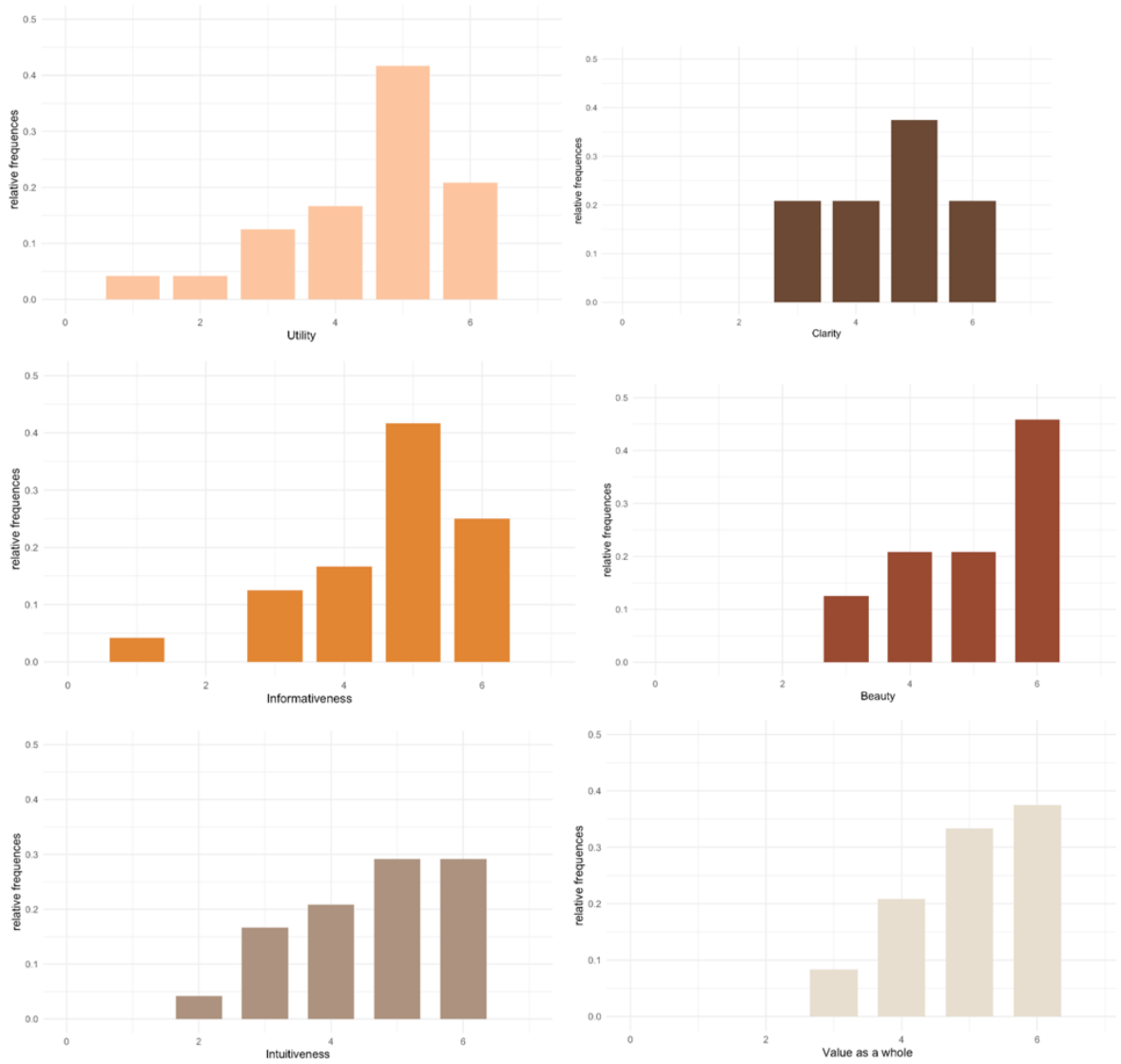

Figure 27: Bar plot of psychometric questionnaire

We can immediately notice that overall we have obtained positive ratings, in fact we can see that more than 40% of the interviewed valued our infographic with the highest value. We can see some low scores for the field of intuitiveness, in fact more than 20% gave a score less than 4. It is probably because most of them are not expert in using or reading visualizations and for this reason they took more time. Some of them told us that this infographic is very useful and clear to understand the importance of the phenomenon that is analyzed, in a matter of fact, plots show that many people have attributed the high value to these fields.
Finally, we are so glad that almost 50% of interviewed appreciated the beauty of our dashboard, because we paid a lot of attention to this part.

Then we realized a boxplot (Figure 28) in order understand better the results of our questionnaire:

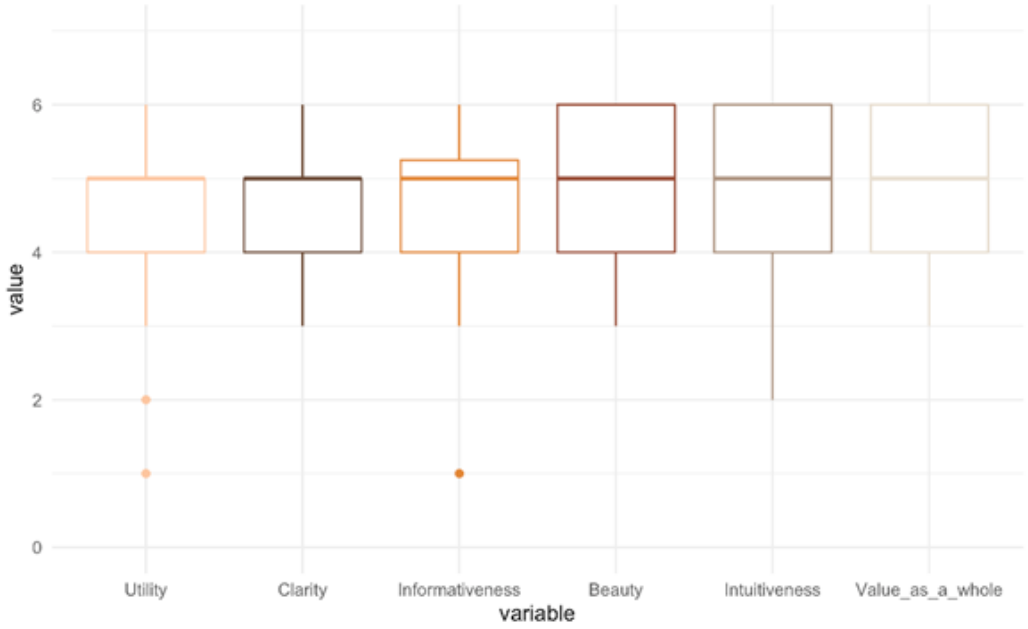

Figure 28: Boxplot of psychometric questionnaire

At a glance we can see that almost 75% of students gave a rating greater than four in each category. We can spot also some outliers in the Utility distribution, in fact we have only two people that evaluated our infographic not very useful. We have obtained also a median equal to 5 for each category, so this means that 50% of our interviewed gave a score equal or more than 5.
The density distribution is non evident in the boxplot, thus we generated also a violin plot (Figure 29) to show it.

Figure 29: Violin plot of psychometric questionnaire

What has been said so far is confirmed by the following stacked bar chart, made using two categories "good" (score 1-3) "bad" (score 4-6).

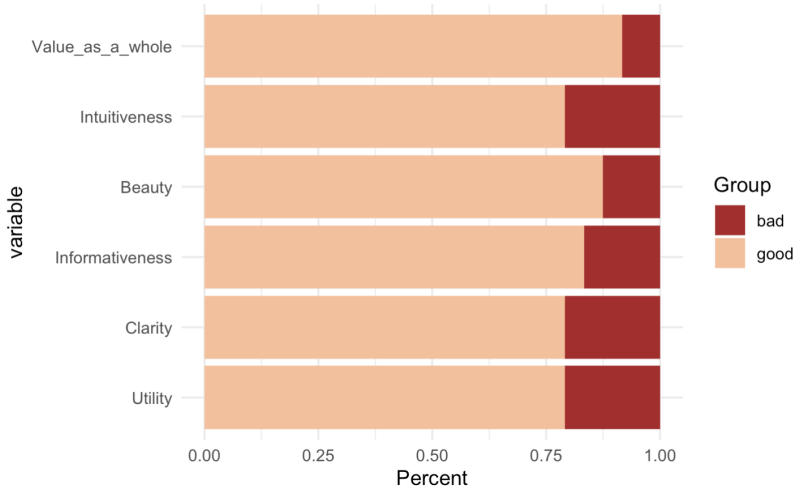

Figure 30: Stacked bar chart of psychometric questionnaire

Finally, we saw if there was a correlation between the different categories presented in the questionnaire and to do this we created a corrplot (Figure 31):

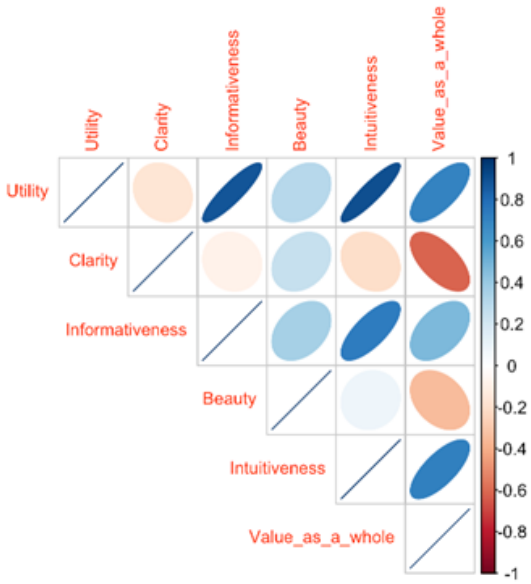

Figure 31: Corrplot of psychometric questionnaire

It is evident a strong positive correlation between utility and informativeness and also among utility and clarity, this means that people who rated usefulness high, rated informativeness and intuitiveness equally high. Indeed, if the infographic were not informative it could not be useful for the viewer.

5 Conclusions: *where's the beef?*

This analysis has provided valuable insight into the significant impact of meat consumption on the environment. Through an examination of historical trends in meat consumption over the past 60 years, we have been able to see a general upward trend in meat consumption, as well as variations in consumption patterns for different types of meats and regions. Furthermore, our research has highlighted the substantial role that meat production plays in the production of CO2 and other greenhouse gases.

As a result of this analysis, we are compelled to consider the steps that can be taken to mitigate the negative effects of meat consumption on the environment. From reducing individual meat consumption to supporting more sustainable and responsible farming practices, there are a variety of actions that can be taken to address this important issue. The findings of this report serve as a call to action for individuals, businesses, and policymakers alike to take meaningful and effective steps to reduce the environmental impact of meat consumption. By reducing the amount of meat we eat and striving for a more sustainable diet, each of us can help to reduce the damage to the environment. As new technology and legislation are introduced, we can all make a difference in protecting the planet with our dietary choices.

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