The Unsustainability of Food Production

COS30045 Data Visualisation Project Process Book

Janice Ridwan

101994340

https://mercury.swin.edu.au/cos30045/s101994340/project/datvis.html

Word Count: 4,040

TABLE OF CONTENTS

1 INTRODUCTION

1.1 BACKGROUND AND MOTIVATION

BACKGROUND

Food is essential for humans; however, its production is a massive environmental concern. In recent years, there has been a lot of attention to meat production, which directly contributes to sustainability issues such as carbon dioxide emissions. Other than carbon dioxide emissions, food production results in more problems such as eutrophication, land use that threatens biodiversity, and large amounts of water use.

Eutrophication is a process that "occurs when the environment becomes enriched with nutrients, increasing the amount of plant and algae growth to estuaries and coastal waters" (National Ocean Service, 2020). This occurs naturally by "rock weathering, soil leaching, and rain (natural sources)" (Tusseau-Vuillemin, 2001) however, the food industry is contributing to eutrophication due to the fertilisers used for animal feed or crop production, which often leach into freshwater systems.

Although carbon dioxide is a major part of greenhouse gas emissions, there are other gases that belong are being produced in large amounts in the food industry. Among them, "Methane and nitrous oxide concentrations, mostly from agriculture, have increased by 150% and 20% respectively since 1750." (Climate Change in Australia, 2016). These gases contribute to climate change and global warming.

As demand grows, the land taken up for food production increases. Agriculture, both crops for human consumption and for livestock grazing, takes up "half of all habitable land" (Our World in Data, 2020). This land conversion to agriculture is "thought to threaten wildlife and biodiversity to a degree that is on par with climate change" (Aberg, 2019). Lastly, "the way people use water in agriculture is the most significant contributor to ecosystem degradation and to water scarcity" (Molden, et al. 2007). This is due to the large amounts of crops produced worldwide, which of course requires more and more water as the demand increases each year.

MOTIVATION

This visualisation is intended to show the general public how the modern food production industry is incredibly unsustainable, as well as provide steps for consumers to decrease this negative environmental impact. As someone who is trying to live more sustainably through various, small measures such as purchasing products with less packaging, this is a topic that I was interested in being informed with.

1.2 PROJECT OBJECTIVES

This project aims to answer many questions related to the sustainability of food production and how we might be able to understand what we contribute towards the current condition. Some questions include:

- What are the environmental impacts of food production?
- How does the land use for agriculture compare to livestock?
- How much C02 and GHG emissions is food production responsible for?
- How can we decrease the impact of food production towards the environment?

My aims following the completion of the project were to:

- Learn and accomplish a better understanding of the carbon footprint of food production.
- Understand what causes the GHG emissions and why it’s detrimental to the environment.
- Find solutions to the issues at hand, such as decreasing meat consumption.

After finishing the visualisation, I became more informed regarding the environmental issues caused by our food production system. Seeing the values and comparing between each food product it is obvious that some products are better for the environment than others, namely beef, and I have reduced my meat consumption since the start of this project. As it has affected me enough to make changes in my lifestyle and diet, hopefully it will be equally beneficial for the users, whether they would alter their lifestyles as part of the solution provided by the completed visualisation or not.

2 DATA

2.1 DATA SOURCE

Product	Nutr. Units / FU	Resampled, Randomized Data Land Use (m^2/nutritional unit)						GHG Emissions (kg CO_2eq/NU, IPCC 2013 incl CC feedbacks)						GHG Emissions (kg CO_2eq/NU, IP		
		5th pctl	10th pctl	Mean	Median	90th pctl	95th pctl	5th pctl	10th pctl	Mean	Median	90th pctl	95th pctl	5th pctl	10th pctl	Mean
Wheat & Rye (Bread)	2.7	0.4	0.4	1.4	1.0	2.9	3.7	0.3	0.3	0.6	0.5	0.9	1.1	0.3	0.3	0.6
Maize (Meal)	4.5	0.2	0.3	0.7	0.4	1.3	2.0	0.1	0.2	0.4	0.3	0.5	0.8	0.1	0.2	0.4
Barley (Beer)	5	0.04	0.1	0.2	0.2	0.5	0.6	0.1	0.1	0.2	0.2	0.3	0.4	0.1	0.1	0.2
Oatmeal	2.6	1.0	1.1	2.9	2.9	4.9	5.3	0.3	0.3	0.9	1.0	1.6	1.6	0.3	0.3	0.9
Rice	3.7	0.3	0.3	0.8	0.6	1.7	2.0	0.3	0.4	1.2	1.0	2.4	2.8	0.3	0.3	1.0
Potatoes	0.7	0.5	0.6	1.2	1.1	1.9	2.3	0.1	0.2	0.6	0.6	0.9	1.0	0.1	0.2	0.6
Cassava	1.0	0.7	0.8	1.9	1.4	3.3	3.4	0.3	0.4	1.4	1.1	2.2	2.3	0.3	0.3	1.3
Cane Sugar	-	1.1	1.2	2.0	1.8	3.1	3.5	0.6	0.9	3.2	3.2	5.1	5.6	0.6	0.9	3.2
Beet Sugar	-	1.1	1.2	1.8	1.5	3.1	3.3	1.0	1.2	1.8	1.8	2.4	2.6	1.0	1.2	1.8
Other Pulses	2.1	1.9	4.6	7.3	5.7	19	20	0.4	0.5	0.8	0.6	1.8	1.9	0.4	0.5	0.8
Peas	2.2	1.0	1.2	3.4	3.0	6.4	9.2	0.2	0.3	0.4	0.4	0.8	0.8	0.2	0.3	0.4
Nuts	1.6	2.5	2.7	7.9	5.3	16	16	-2.5	-2.2	0.3	-0.8	2.4	6.6	-2.4	-2.3	0.2
Groundnuts	2.6	1.6	1.8	3.5	3.0	5.9	5.9	0.5	0.6	1.2	1.3	2.2	2.3	0.5	0.6	1.2
Soymilk	-	0.3	0.3	0.7	0.6	0.9	1.1	0.5	0.6	1.0	0.9	1.5	1.7	0.5	0.6	1.0
Tofu	1.6	1.0	1.1	2.2	2.1	3.1	3.7	0.9	1.0	2.0	1.6	3.5	4.5	0.9	1.0	2.0
Soybean Oil	-	4.8	5.3	11	10	15	17	2.2	2.4	6.3	3.9	13	19	2.2	2.4	6.2
Palm Oil	-	1.4	1.7	2.4	2.4	3.0	3.3	2.8	3.6	7.3	7.2	12	13	2.4	3.4	7.2
Sunflower Oil	-	7.5	8.4	18	16	27	30	2.2	2.5	3.6	3.5	4.6	4.9	2.2	2.4	3.6
Rapeseed Oil	-	5.0	5.2	11	9.4	19	21	2.2	2.5	3.8	3.5	4.6	7.2	2.2	2.5	3.8
Olive Oil	-	7.9	7.9	26	17	36	36	2.1	2.9	5.4	5.1	7.6	11	2.1	2.9	5.3
Tomatoes	-	0.1	0.1	0.8	0.2	0.9	5.6	0.4	0.4	2.1	0.7	6.0	13	0.4	0.4	2.0

Figure 1 Poore & Nemecek (2018), Note: Data source provided in references

This visualisation uses data from Poore and Nemecek (2018), shown in Figure 1, which is very clean and detailed. This allows me to forgo data cleaning as there is no noise or inconsistencies within the data. The dataset contains information of land use, greenhouse gas emissions, eutrophication and freshwater use of different food products. Another dataset that is used within this visualisation is from Our World in Data. These values are already clean hence no data cleaning will be performed.

Food product	Land use change	Animal Feed	Farm	Processing	Transport	Packging	Retail
Wheat & Rye (Brea	0.1	0	0.8	0.2	0.1	0.1	0.1
Maize (Meal)	0.3	0	0.5	0.1	0.1	0.1	0
Barley (Beer)	0	0	0.2	0.1	0	0.5	0.3
Oatmeal	0	0	1.4	0	0.1	0.1	0
Rice	0	0	3.6	0.1	0.1	0.1	0.1
Potatoes	0	0	0.2	0	0.1	0	0
Cassava	0.6	0	0.2	0	0.1	0	0
Cane Sugar	1.2	0	0.5	0	0.8	0.1	0
Beet Sugar	0	0	0.5	0.2	0.6	0.1	0
Other Pulses	0	0	1.1	0	0.1	0.4	0
Sugars and Pulses	1.2	0	2.1	0.2	1.5	0.6	0
Peas	0	0	0.7	0	0.1	0	0
Nuts	-2.1	0	2.1	0	0.1	0.1	0
Groundnuts	0.4	0	1.4	0.4	0.1	0.1	0
Nuts (Total)	-1.7	0	3.5	0.4	0.2	0.2	0
Soymilk	0.2	0	0.1	0.2	0.1	0.1	0.3
Tofu	1	0	0.5	0.8	0.2	0.2	0.3
Soy Products	1.2	0	0.6	1	0.3	0.3	0.6
Soybean Oil	3.1	0	1.5	0.3	0.3	0.8	0

Figure 2 Our World in Data (2020), Note: data source provided in references. This particular data source was obtained from a chart.

2.2 DATA PROCESSING

SUBPRODUCTS

As I won't be using the whole dataset from Poore and Nemecek (2018), I extracted the required information into a separate file in Excel. I took the mean values of the randomised data for land use, GHG emissions, freshwater use and eutrophying emissions and copied them to a new .csv file.

	Resampled, Randomized Data											
	Land Use (m^2/FU)						GHG Emissions (kg CO_2eq/FU, IPCC 2013 incl. CC feedbacks)					
Product	5th pctl	10th pctl	Mean	Median	90th pctl	95th pctl	5th pctl	10th pctl	Mean	Median	90th pctl	95th pctl
Wheat & Rye (Bread)	1.0	1.1	3.9	2.7	7.9	10.0	0.7	0.8	1.6	1.3	2.3	3.
Maize (Meal)	1.0	1.1	2.9	1.8	5.7	9.0	0.7	0.7	1.7	1.2	2.3	3.
Barley (Beer)	0.2	0.3	1.1	0.9	2.4	2.9	0.6	0.7	1.2	1.2	1.6	1.
Oatmeal	2.6	2.9	7.6	7.7	12.9	14.0	0.8	0.9	2.5	2.6	4.1	4.
Rice	1.0	1.1	2.8	2.2	6.2	7.2	1.2	1.5	4.5	3.7	8.8	10.
Potatoes	0.4	0.4	0.9	0.8	1.4	1.7	0.1	0.2	0.5	0.5	0.6	0.
Cassava	0.7	0.8	1.8	1.3	3.2	3.3	0.3	0.4	1.3	1.1	2.1	2.
Cane Sugar	1.1	1.2	2.0	1.8	3.1	3.5	0.6	0.9	3.2	3.2	5.1	5.
Beet Sugar	1.1	1.2	1.8	1.5	3.1	3.3	1.0	1.2	1.8	1.8	2.4	2.
Other Pulses	4.1	9.9	15.6	12.2	41.3	41.9	0.9	1.0	1.8	1.4	3.8	4.
Peas	2.3	2.8	7.5	6.7	14.2	20.5	0.5	0.6	1.0	0.8	1.7	1.
Nuts	4.2	4.5	13.0	8.7	26.6	26.6	-4.0	-3.7	0.4	-1.3	3.8	10.
Groundnuts	4.2	4.7	9.1	7.9	15.4	15.4	1.4	1.6	3.2	3.3	5.8	6.
Soymilk	0.3	0.3	0.7	0.6	0.9	1.1	0.5	0.6	1.0	0.9	1.5	1.
Tofu	1.6	1.8	3.5	3.4	4.9	5.9	1.4	1.6	3.2	2.6	5.6	7.
Soybean Oil	4.8	5.3	10.5	9.6	14.6	17.5	2.2	2.4	6.3	3.9	13.4	18.
Palm Oil	1.4	1.7	2.4	2.4	3.0	3.3	2.8	3.6	7.3	7.2	12.0	13.
Sunflower Oil	7.5	8.4	17.7	16.3	27.0	29.7	2.2	2.5	3.6	3.5	4.6	4.

Figure 3 Highlighted columns of resampled, randomised data of Land Use and GHG Emissions

Products were then aggregated using the SUM() function in Excel into relevant categories as follows:

1. Grains: Wheat & Rye (Bread), Maize (Meal), Barley (Beer), Oatmeal, Rice
2. Pulses: Rice, Cane Sugar, Beet Sugar, Other Pulses
3. Legumes: Peas, Nuts, Groundnuts, Soymilk, Tofu
4. Oils: Soybean Oil, Palm Oil, Sunflower Oil, Rapeseed Oil, Olive Oil
5. Vegetables: Onions & Leeks, Root Vegetables, Brassicas, Other Vegetables
6. Fruit: Citrus Fruit, Bananas, Apples, Berries & Grapes, Wine, Other Fruit, Tomatoes
7. Coffee
8. Dark Chocolate
9. Beef: Beef (beef herd and dairy herd)
10. Other Meat: Lamb & Mutton, Pig Meat, Poultry Meat
11. Dairy: Milk, cheese, eggs
12. Seafood: Fish (farmed), Crustaceans (farmed)

This resulted in Figure 4, subproducts.csv which will be used to create a stacked bar chart.

Product	Land	GHG	Freshwater	Eutrophying
Grains	18.3	11.4	36.1	59.8
Pulses	19.4	6.8	12.7	39.4
Legumes	26.3	7.8	61.6	40.5
Oils	54.6	12.8	33.9	107.1
Vegetables	5.1	5.8	6.9	23.8
Fruit	8.5	6.1	10.3	20.1
Coffee	21.6	28.5	0.3	110.5
Dark Chocolate	69	46.7	5.4	87.1
Beef	369.5	132.8	41.7	666.7
Other Meat	399.4	61.9	42.6	222.2
Dairy	103	31.7	68.1	130.8
Seafood	11.4	40.5	72.1	462.3

Figure 4 subproducts.csv

Attribute	Description	Type	Subtype
Product	This attribute describes the name of each product category such as Fruit or Coffee.	Categorical	Nominal
Land	This attribute contains the Land Use (m^2/FU) of each product.	Numeric	Continuous
GHG	This attribute contains the GHG emissions (kgCOeq/FU) of each product.	Numeric	Continuous
Freshwater	This attribute contains the Freshwater Use (kL/FU) of each product.	Numeric	Continuous
Eutrophying	This attribute contains the Eutrophying Emissions (bleh/FU) of each product.	Numeric	Continuous

EMISSIONS IN THE SUPPLY CHAIN

The data from Our World in Data shown in Figure 2 takes information from the Poore and Nemecek (2018) research, hence the products are the same. For my charts, I aggregated products into subgroups to allow the visualisation to look less full and cluttered. This aggregation was done simply, using the SUM() function in Excel. The results are shown in Figure 5.

	A	B	C	D	E	F	G	H	I
1	Product	Land	Feed	Farm	Processing	Transport	Packaging	Retail	
2	Grains anc	1.6	0	8.6	0.7	1.9	1.5	0.5	
3	Produce a	5.9	0	21	4.3	3.5	5.9	0.6	
4	Coffee	3.7	0	10.4	0.6	0.1	1.6	0.1	
5	Chocolate	14.3	0	3.7	0.2	0.1	0.4	0	
6	Beef	17.2	4.4	55.1	2.4	0.7	0.5	0.4	
7	Other Mea	4.5	7.1	21.9	1.8	1.1	0.8	0.6	
8	Dairy	5.7	4.7	15.9	0.8	0.3	0.5	0.6	
9	Seafood	0.7	3.3	12	0	0.3	0.4	0.2	
10									

Figure 5 GHG_lifecycle.csv

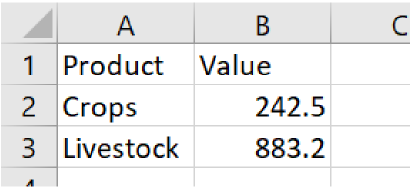
Produce and Oils consists of Vegetables, Fruits, Oils, Legumes. Instead of grouping dark chocolate and coffee into a group together or to 'Produce and Oils', I decided to leave them alone. This allows viewers to see the impact of things that we would consider trivial. Similarly, I grouped all vegetables, fruits, nuts, soy products and vegetable oils together to show that even when aggregated, the emissions from produce is far less compared to meat.

Attribute	Description	Type	Subtype
Product	This attribute describes the name of each product category such as Fruit or Coffee.	Categorical	Nominal
Land	This attribute represents emissions from the land use of the products.	Numeric	Continuous
Feed	This attribute shows the emissions from crop production to feed livestock.	Numeric	Continuous
Farm	This attribute is the methane produced by animals, rice, emissions from fertilisers and machinery.	Numeric	Continuous
Processing	This attribute covers the emissions from converting raw food to final food items.	Numeric	Continuous
Transport	This attribute is the emissions from transport both local and internationally.	Numeric	Continuous
Packaging	This attribute covers the emissions from production of packaging material and end-of-life disposal.	Numeric	Continuous
Retail	This attribute is emissions from refrigeration and other processes.	Numeric	Continuous

LIVESTOCK VS. AGRICULTURE DATA

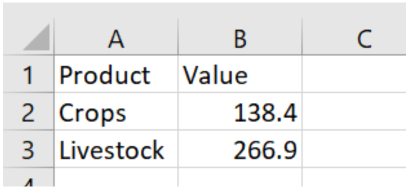
A further generalisation was applied to the data from Poore and Nemecek (2018), resulting in only two attributes: livestock and crops. These are split into two files, total_land.csv and total_ghg.csv shown below.

1. Livestock: Meat, Dairy, Seafood
2. Crops: Grains and Pulses, Produce and Oils, Dark Chocolate, Coffee



	A	B	C
1	Product	Value	
2	Crops	242.5	
3	Livestock	883.2	

Figure 6 land_data.csv



	A	B	C
1	Product	Value	
2	Crops	138.4	
3	Livestock	266.9	

Figure 7 ghg_data.csv

Attribute	Description	Type	Subtype
Product	This attribute describes the name of each product category such as Fruit or Coffee.	Categorical	Nominal
Value	This attribute represents land used for the product or the GHG emissions.	Numeric	Continuous

3 VISUALISATION FEATURES

3.1 MUST-HAVE FEATURES

To set the foundations of the visualisation before the design process I decided some features that should be put into the visualisation. This includes features that must be present and some that would improve the visualisation.

LIVESTOCK VS. AGRICULTURE

As the aim of this visualisation is to show the impact of food production, it is a must have feature to compare both the greenhouse gas emissions and land use between the two major food groups: agriculture and livestock.

- Bar chart, with land use and GHG emissions encoded by hue and the values encoded by the length of the bars.
- Pie charts for both land use and greenhouse gas emissions, showing the percentage of each
- Axes and labels for bar chart, so user will know what they are viewing

- Buttons to allow the user to view either land use or greenhouse gas emissions. These buttons share the same hue as their respective charts.
- Tooltips with a box containing the product name and value showing up when the user hovers over a bar, alongside a change in the bar colour.
- Animated with a transition when the user clicks a button to view a different chart

CARBON FOOTPRINT

This section of the visualisation aims to show users the greenhouse gas emissions within each lifecycle for a certain group of food products. The chart should depict the large difference between animal products and crops within all stages of the lifecycle, further showing the damage of animal products if we resume production at the current rate.

- Stacked bar chart
  - Each stack in the series is encoded by hue due to their categorical nature, and the values are encoded by the length of each stack.
- Tooltips are used to show which stage the user is hovering over, along with the values.
- The hues recorded in a legend, with the supply chain stage written next to its corresponding hue.

WHAT CAN WE DO?

This section of the visualisation summarises the main findings from the charts within the webpage. It gives the viewers a way to decrease their personal impact towards the environment when consuming food.

3.2 OPTIONAL FEATURES

CHLOROPLETH

- Map of world or region
  - Bubbles to show the values, encoded as the area of the circle
  - Hues could be used to encode the data being shown such as land use or freshwater use
  - Buttons to filter
- Explanation of the map as it might be confusing

An optional feature that I was not able to achieve was a chloropleth to depict the areas that produce the largest amount of emissions or land use. I did not go through with this feature as I was unable to find a dataset that would be appropriate for producing this chart.

BREAKDOWN OF GHG EMISSIONS WITHIN FOOD INDUSTRY

- Chart to visualise the breakdown
    - Bar chart with values encoded by the length of the bar
    - Axes and labels
- Buttons to filter the data
    - Encoded with the same hue as their corresponding charts
- Tooltips with values and transitions

COMPARING CARBON-FOOTPRINT OF AGRICULTURE AND MEAT

- Chart to visualise
    - Stacked bar chart
        - Each stack in the series is encoded by hue with values are encoded by the length of each stack.
    - Pie chart
        - Each slice with a different hue
        - Percentage values given
- Tooltips are used to show which stage the user is hovering over, along with the values.
- Legend for users to know what each hue represents

I decided against producing a chart comparing the carbon footprint of agriculture and meat as I believe the stacked bar chart will make an impact on the viewers without a general comparison. Creating another chart would have been redundant, not giving any knowledge or interest to viewers.

4 VISUALISATION DESIGN

4.1 GENERAL IDEAS

Instead of creating one all-encompassing chart for my visualisation, I decided to create a more 'traditional' scroll-down webpage with many charts showing different data. This would allow me to relay the information to users as a story, showing the charts alongside explanation on the values and what they mean.

There are four sections to the visualisation: 'Livestock vs. Agriculture', 'Breaking Down the Groups', 'Carbon Footprint' and 'What Can We Do'. 'Livestock vs. Agriculture' visualises categorical data hence I considered bar charts and pie charts, the same goes for 'Breaking Down the Groups'.

'Carbon Footprint' will be using data from subproducts.csv in Figure 4, and since there are many attributes it would be ideal to use a stacked bar chart. Lastly, 'What Can We Do' summarises the whole visualisation and suggests actions that users can take as consumers to decrease their impact on the environment through food production and consumption.

4.2 SKETCHES

Based on the requirements detailed above, below are some sketches of a brainstorm I did for my visualisation. As the visualisation will be comparing categorical data, I considered bar charts, pie charts, stacked bar charts and chloropleth as the visualisation components.

The encoding decisions are based on Munzner's 'Effectiveness Ranks', which ranks marks and channels based on their suitability for certain data types.

BAR CHART

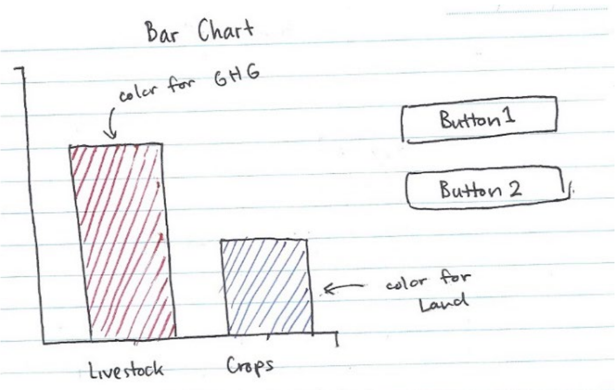


Figure 8 Bar chart sketch

A bar chart could be used for categorical data, which means it can be considered for my visualisation. Figure 7 shows a rough sketch of a bar chart I could use in my visualisation to compare livestock and agriculture. This bar chart could be encoded by hue to show whether it is data for greenhouse gas emissions or land use.

Advantages

- Simple way to convey the values comparing livestock and agriculture
- Shows the large difference between the two groups

Disadvantages

- Only shows the values, it doesn't allow me to depict more causes and effects
- May require more text explanation to give accurate information to the user

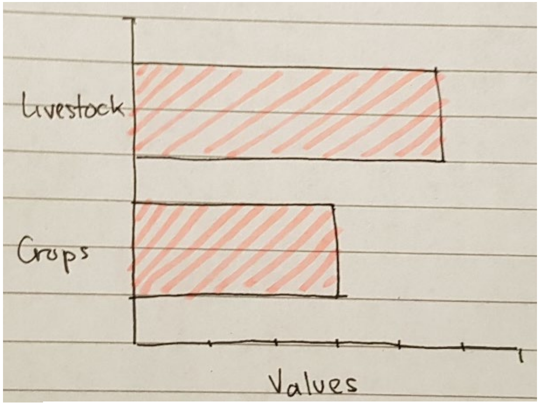


Figure 9 Horizontal bar chart

Features to Implement

- Buttons to switch views from 'Land Use' to 'GHG' chart
- Details on demand: Tooltips featuring a text box with the values
- Transitions when buttons are clicked

Visual Encoding

- Length of the bars
  - Highly effective magnitude channel for quantitative data
- Hue of bars
  - Suitable channel for categorical data (Product attribute).

PIE CHART

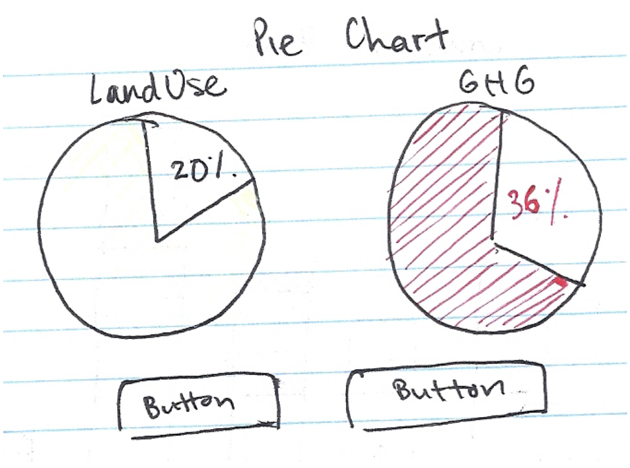


Figure 10 Pie chart sketch

Another chart commonly used to display categorical data is a pie chart. Although this chart isn't ideal for most cases due to the slices likely being of similar sizes, the chart will be used for only two categories, hence it would be easy to tell which one is larger than the other. If I implement a pie chart, it would most likely be an overview, or as a supplementary chart to display percentage values.

Advantages

- Easy to compare values percentage wise with a pie chart
- It is a basic chart that the audience will be able to read
- Only two categories so the values aren't easy to tell apart
- Audience can read the percentages and see it visualised

Disadvantages

- Difficult to animate or apply tooltips and transitions
- Not an ideal way to depict exact values

Features to Implement

- Buttons to switch views from 'Land Use' to 'GHG' chart
- Details on demand: Tooltips featuring a text box with the values
- Transitions when buttons are clicked

Visual Encoding

- Angle
    - Less effective as compared to length and position
    - Can be justified as there are only two attributes shown, with annotations
- Hue of slices
    - Suitable channel for categorical data (Product attribute).

STACKED BAR CHART

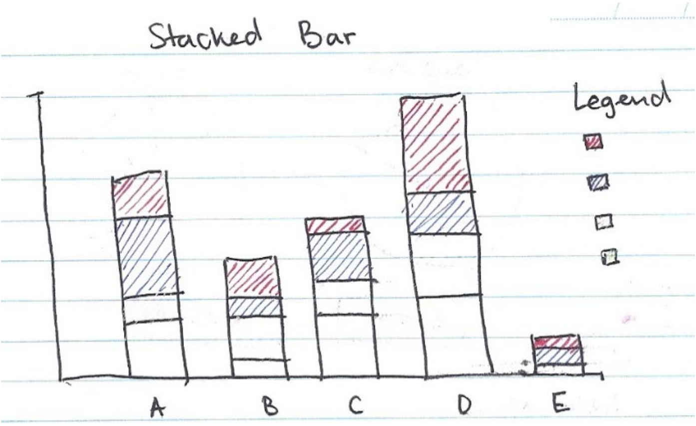


Figure 11 Vertical stacked bar chart

The stacked bar chart would be used to display the emissions in each stage of the supply chain. Using this chart would make it easy to compare nominal values of each stage between two different products. It allows me to use a singular chart rather than multiple bar charts, condensing a lot of information into one chart.

Advantages

- Easy to compare categories as a whole and for each group and within each category
- More interactivity features can be implemented
- Good for target audience

Figure 12 Horizontal stacked bar chart

Disadvantages

- Hard to code negative values and compared to bar and pie charts
- If there are many stacks, it becomes hard to read the chart

Features to Implement

- Legend and tooltips pop up when hovering over a bar
- Filtering stacks to include or exclude
- ‘Zoom’ to focus on one part of the bar.

Visual Encoding

- Length of the bars
  - Is a very effective magnitude channel for quantitative data, as Land Use, GHG, Eutrophying Emissions and Freshwater Use are.
- Hue of bars
  - Suitable channel for categorical data (Product attribute).

CHLOROPLETH

Figure 13 Chloropleth sketch

A chloropleth would be a good option for a visualisation as it allows me to apply a lot of interactive features for the user to explore. However, it is difficult to find a dataset that would contain the required values to produce a chloropleth, and the encoding must be clear as to not mislead the audience. My ideas for a chloropleth would be to include a key, tooltips and allow a zoom into certain regions, however that may be too difficult to code.

Advantages

- Very interesting and can apply many features and interactivity
- Can display a lot of information compared to bar charts for some cases (e.g. data for each country or state)

Disadvantages

- Difficult to produce
- Hard to find a suitable dataset for a chloropleth

Features to Implement

- Legend for any encoding
- Zoom and filter to a state or country
- Tooltips when hovering over a region

Visual Encoding

- Bubbles as area to represent values
    - Right in the middle of the effectiveness chart for numeric data, so it is suitable
- Hue for categories or different data showing
    - Suitable channel for categorical data.

4.3 DESIGN EVOLUTION

After designing the website through sketches, I had solid idea on the what I wanted my visualisations to look like. For the first visualisation on livestock vs. agriculture, I implemented a vertical bar chart. The first iteration of this bar chart is done in a different colour scheme than the second and final iteration, which is after I decided the colours to implement in my visualisation.

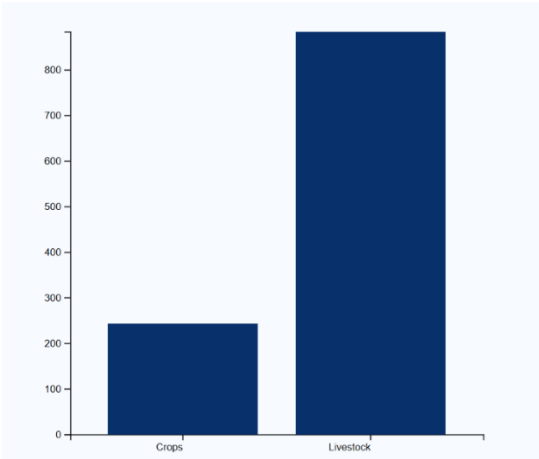


Figure 14 First Bar Chart Iteration

After tweaking the axes labels and chart sizes, I created buttons to switch between two charts, one for land use and the other for GHG emissions. Land Use is encoded with a green hue while GHG is encoded with blue. This is represented in the buttons. Although the bar chart displays values accurately, I felt that it wasn't enough. At this point, I decided to add pie charts into the visualisation, showing the percentages of the values. Instead of creating buttons for them like the bar chart, it's visually better to have both charts displayed statically with the percentage values on them.

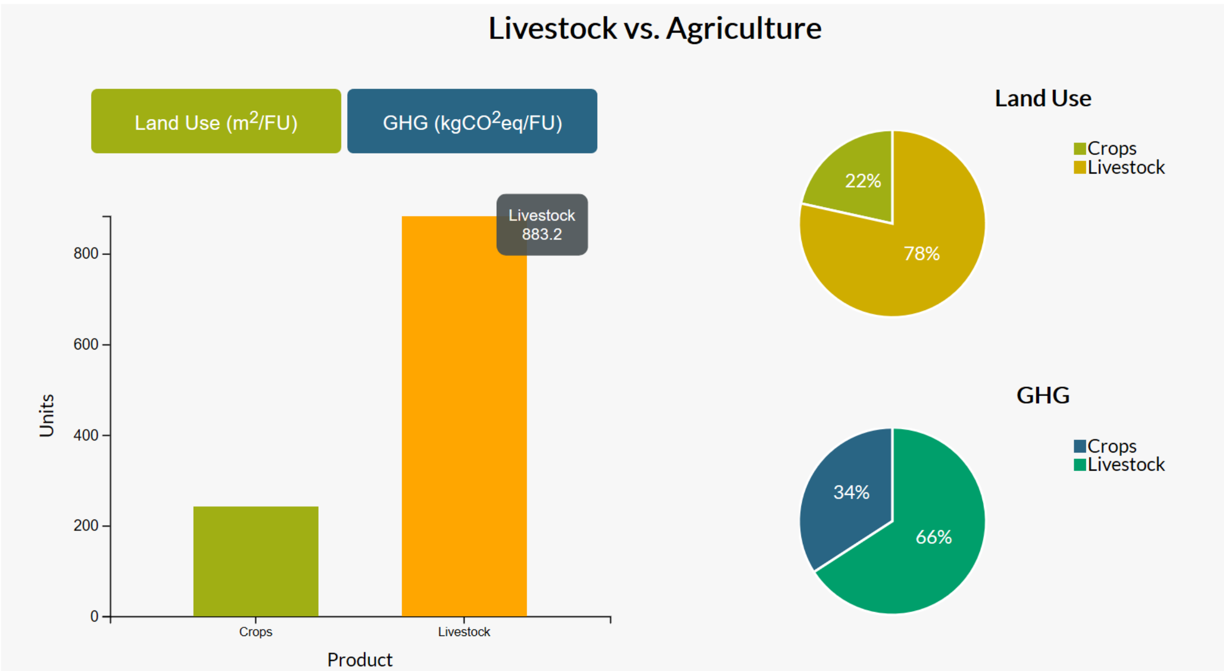


Figure 15 Livestock VS. Agriculture visualisation

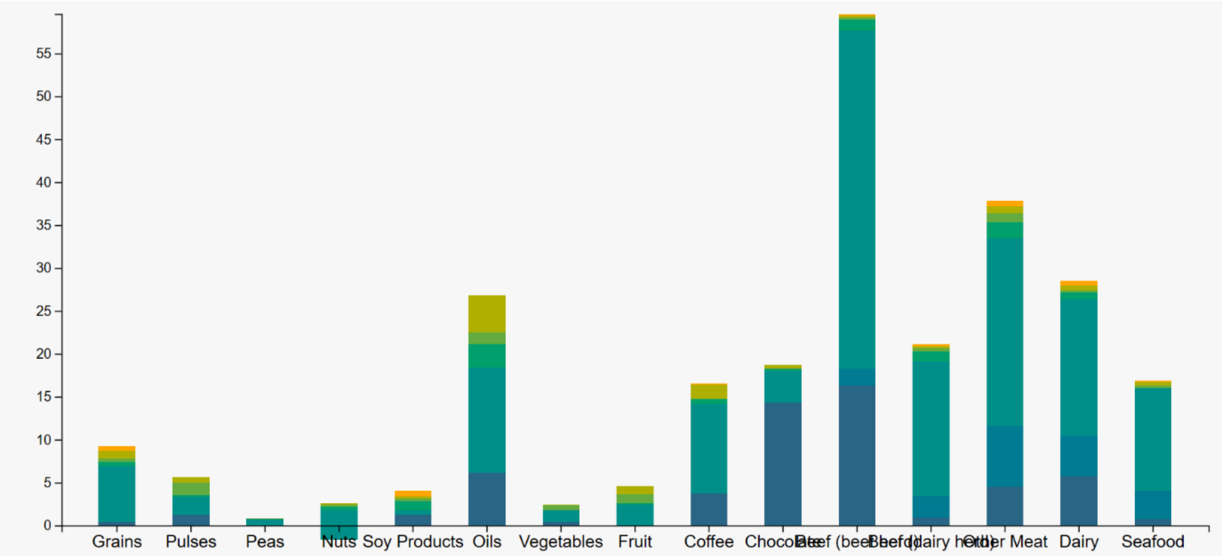
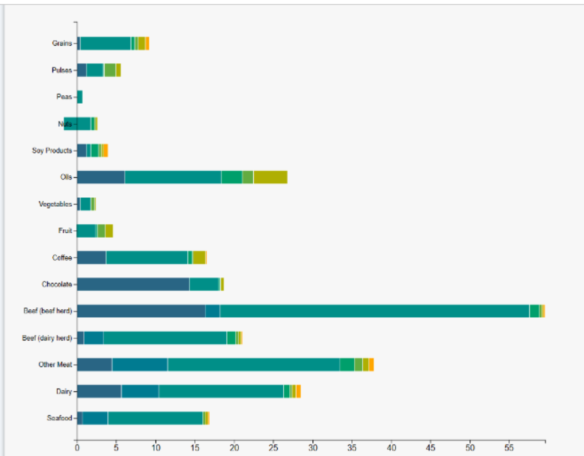


Figure 16 Vertical stacked bar iteration

For the stacked bar chart, I initially started with more categories than the final iteration. The first chart produced is Figure 16, and the next was a test on changing it into a horizontal chart Figure 17. This doesn't look as good, hence I decided to keep it vertical and decrease the categories.



Afterwards I added tooltips where upon hovering, a text box will show the value and which category it is. An additional zoom and filter feature is when the user hovers over a section, it will highlight that section and bring the focus towards that particular part of the chart. The final iteration is shown in Figure 18, with the tooltip and opacity feature shown in Figure 19.

Figure 17 Horizontal stacked bar iteration

The categories were decreased by aggregating products into one larger 'subproduct' category. This was done logically and with the impact of the values in mind, all produce and oils were summed into one category to show that even when aggregated, they are producing far less emissions than their other counterparts such as beef and other meat.

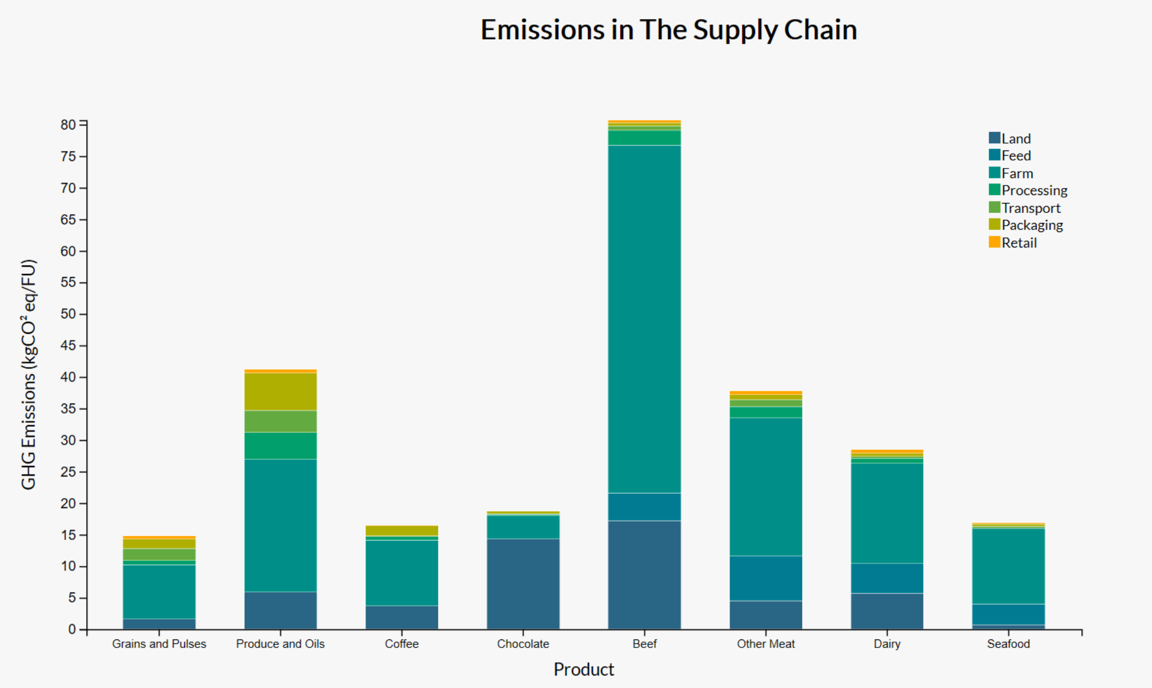


Figure 18 Final stacked bar chart

Figure 18 shows the final iteration with the legend in place. The chart has axes labels, and the tooltip feature which is shown in Figure 19. The chart has spaces between the bars for clarity, and each stack has a white outline so the hues can be differentiated from each other easier.

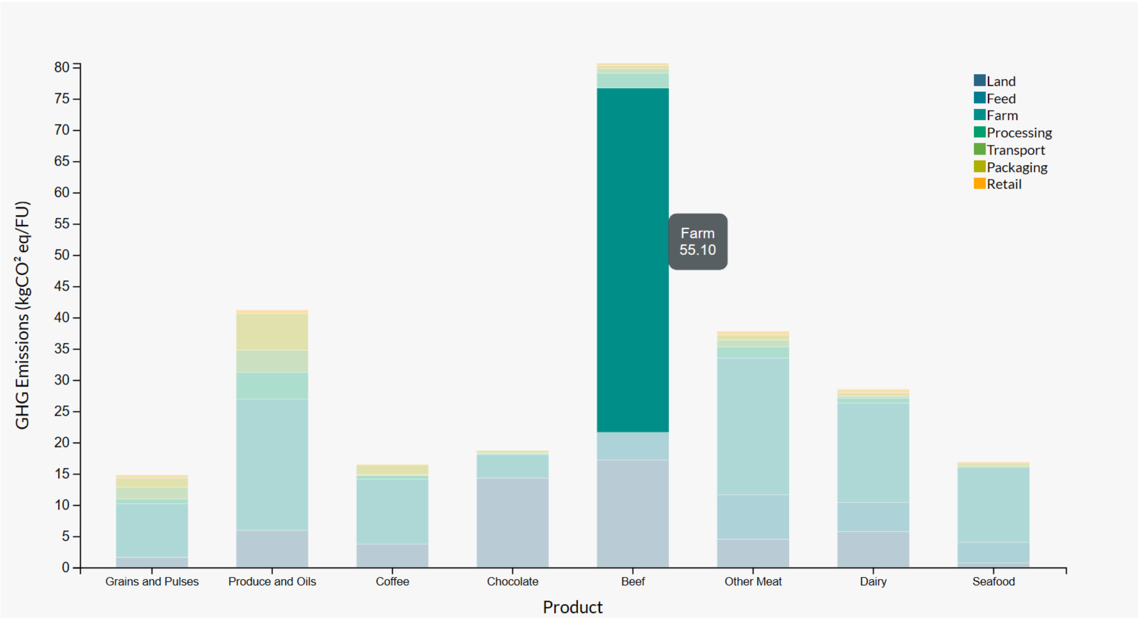


Figure 19 Tooltips for stacked bar

The last chart, Figure 20, in the visualisation has similar features as the chart for 'livestock vs. agriculture'. It features buttons that allow the user to switch between different charts, encoded by hue depending on which chart they are viewing. All the charts are labelled with a title and axes labels, as well as values on the y-axis and the category name on the x-axis. When hovered over, each bar will turn yellow with a text box showing the category name and value.

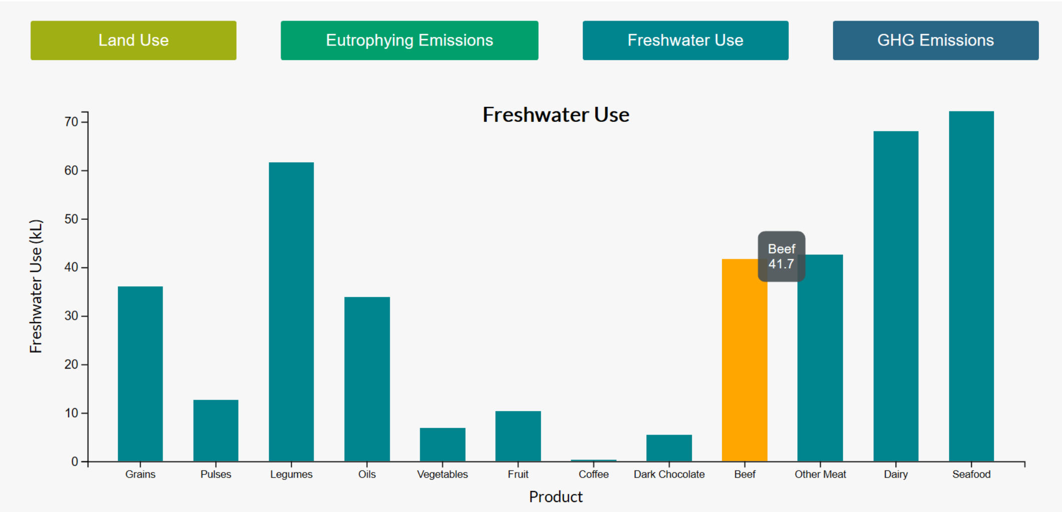


Figure 20 Bar chart tooltips

All the charts feature details on demand and give an overview of the chart. Although due to time constraints and the chart types I chose I was unable to implement zoom and filter features, the whole visualisation narrows down from an overview with 'Livestock Vs. Agriculture' to the subgroups, and to the emissions in the supply chain stacked bar chart.

The hues chosen for the entire visualisation are:

These were obtained from Data Color Picker (2019).

4.4 FINAL VISUALISATION

Lastly, in this section I will provide more screenshots of the charts in the final visualisation that have not been presented previously. Many of the final visualisations reuse code provided in the D3 Graph Gallery and the unit material.

The first visualisation gives an overview of the whole project, showing bar charts and pie charts with values and percentages of the impact food production has on the environment. These charts were designed with minimal noise and within the same colour scheme, and appropriate marks and channels were used for the data types.

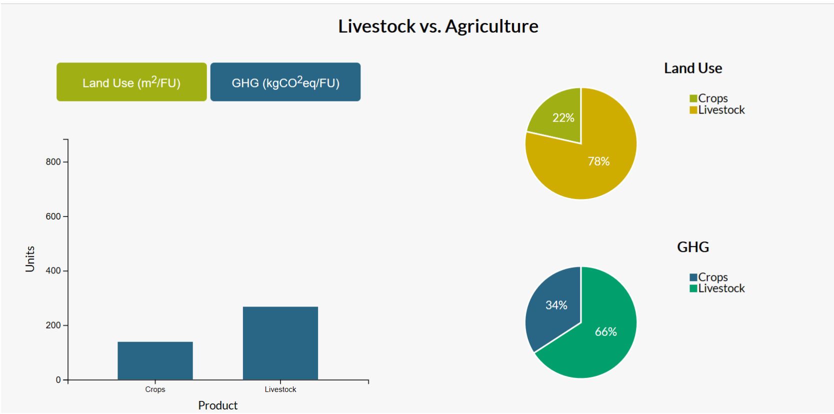


Figure 21 Livestock vs. Agriculture, GHG chart

Figures 22 to 24 belong to the same visualisation, which shows the land use, emissions and freshwater use of some food product categories. This, again, follows appropriate marks and channels (length of the bars for the values, hue for different charts). The user is able to interact with the visualisation by pressing buttons which bring up different charts. These charts allow the audience to compare between the categories provided.

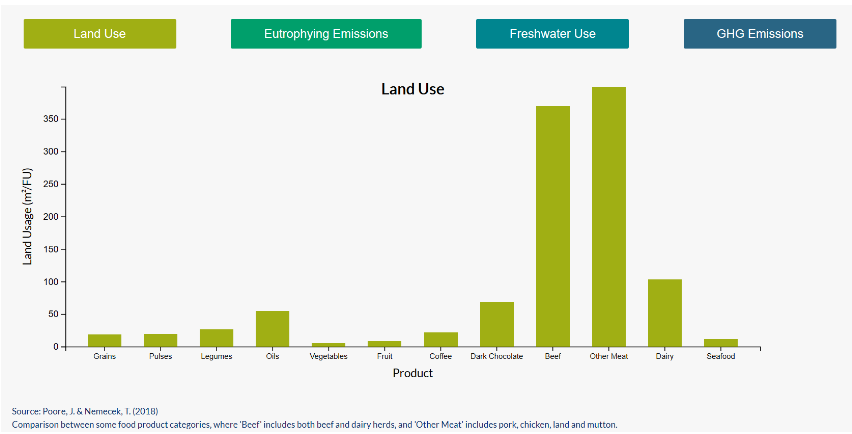


Figure 22 Land Use subproducts.csv

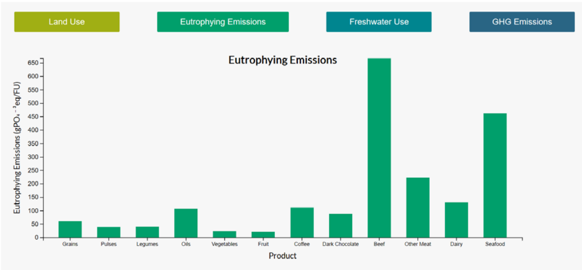


Figure 23 Eutrophying Emissions subproducts.csv

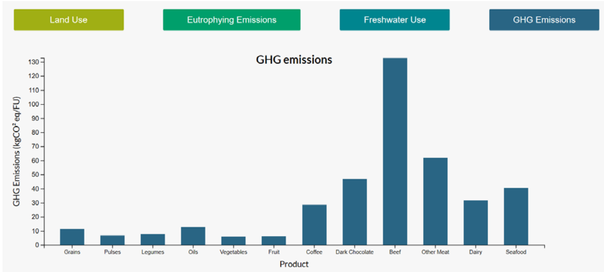


Figure 24 GHG Emissions subproducts.csv

Figure 25 is a stacked bar chart with proper encoding of marks and channels, allowing users to compare between each category and lifecycle stage. All the charts follow the same colour scheme which makes the webpage appear cohesive and like they belong together, which is what you would want.

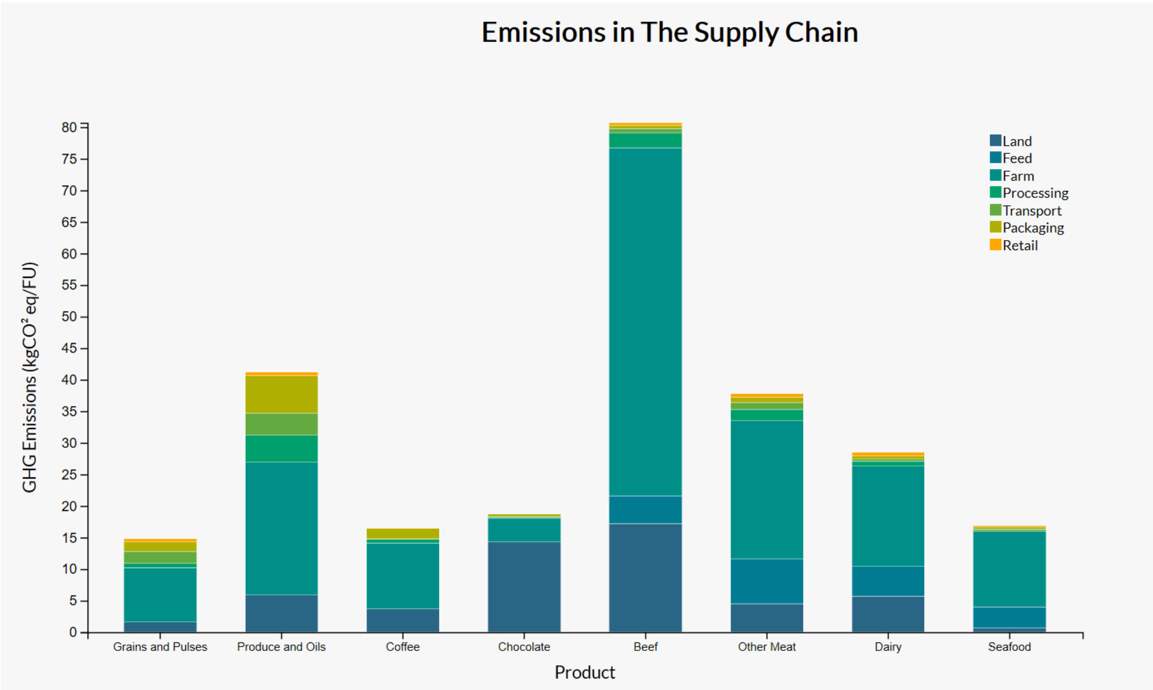


Figure 25 Final stacked bar chart

5 CONCLUSION

After completing my project, I have learned many things regarding my topic, and I believe I have achieved all the objectives I started with, such as:

- The environmental impacts of food production.
    - Large use of land, large GHG emissions which contributes to climate change, eutrophying emissions which increases the rate of eutrophication, large freshwater use which is a worry due to water scarcity.
- Comparison of land use between agriculture and livestock.
    - Agriculture uses much less land than livestock farming does.
- How much C02 and GHG emissions food production is responsible for.
    - Depicted in the bar charts within the webpage.
- How can we decrease the impact of food production towards the environment?
    - The solution presented in this project is to decrease meat consumption to affect the supply and demand chain.
- Learn about the carbon footprint of food production
    - I learned and presented information of this in the stacked bar chart.

Finally, as written on the webpage and to conclude the project:

All the charts in the webpage show that meat, dairy and seafood overall contribute more towards eutrophication and produce more greenhouse gases, as well as take up more water and land. A large amount land is used for livestock and two-thirds of greenhouse gas emissions stem from animal produce. In fact, just by solely producing and consuming beef from a dairy herd would significantly decrease the impact of beef to the environment.

By lowering the demand for meat, consumers will be able to decrease all the adverse impacts of food production as it will lower the land required for agriculture, decrease the greenhouse gas emissions from livestock farming, and reduce the water required overall.

REFERENCES

NOAA, 2020, *What is Eutrophication?,* NOAA, viewed 5 May 2020, <https://oceanservice.noaa.gov/facts/eutrophication.html>

Poore, J & Nemecek, T 2018, *Reducing food's environmental impacts through producers and consumers*, Science, viewed 15 April 2020, <https://science.sciencemag.org/content/360/6392/987>

Ritchie, H & Roser, M 2020, *Environmental impacts of food production*, Our World in Data, viewed 5 April 2020, <https://ourworldindata.org/environmental-impacts-of-food>

Holtz, Y 2018, *The D3.js Graph Gallery,* the d3.js graph gallery, viewed 15 April 2020, <https://www.d3-graph-gallery.com/>

Tusseau-Vuillemin, M H 2001, *Do Food Processing Industries Contribute to the Eutrophication of Aquatic Systems?*, pubmed.gov, viewed 5 May 2020, <https://pubmed.ncbi.nlm.nih.gov/11689030/#:~:text=Eutrophication%20is%20the%20enrichment%20of,and%20then%20dries%20it%20entirely.>

Molden, D, De Fraiture, C, Rijsberman, F, 2007, *Water Scarcity: The Food Factor*, issues.org, viewed 5 May 2020, <https://issues.org/molden/>

Learn UI Design, 2019, *Data Color Picker*, Learn UI Design, viewed 20 April 2020, <https://learnui.design/tools/data-color-picker.html#palette>

APPENDIX A

Link to working visualisation: https://mercury.swin.edu.au/cos30045/s101994340/project/datvis.html

TOTAL PRODUCTS

https://mercury.swin.edu.au/cos30045/s101994340/project/total_prod.js

```
: > Users > owner > Documents > uni > sem 1 2020 > Data Visualisation > project > JS total_prod.js > barChart
function pieChart1()
{
    var w = 300;
    var h = 180;

    var outerRadius = (w - 150) / 2;
    var innerRadius = 0;
    //set dataset to use
    dataset = land_data;

    //make arcs
    var arc = d3.arc()
                .innerRadius(innerRadius)
                .outerRadius(outerRadius);

    //make pie
    var pie = d3.pie()
                .value(function(d) {
                    return d.Value;
                });

    //create svg
    var svg = d3.select("#pietotal1")
                .append("svg")
                .attr("width", w)
                .attr("height", h)
                .attr("transform", "translate(" + w/2 + "," + h/2 + ")");

    var color = d3.scaleOrdinal(["#a0af14", "#cfad00", "#ffa600"]);

    var arcs = svg.selectAll("g.arc")
                    .data(pie(dataset))
                    .enter()
                    .append("g")
                    .attr("class", "arc")
                    .attr("transform", "translate(" + outerRadius + "," + outerRadius + ")");

    arcs.append("path")
        .attr("fill", function(d){return color(d.data.Product)})
        .attr("stroke", "white")
        .attr("stroke-width", "2px")
        .attr("d", arc);

    arcs.append("text")
        .text(function(d) {
            return Math.round((d.endAngle - d.startAngle)/(2*Math.PI)*100) + "%";
```

SUB PRODUCTS

https://mercury.swin.edu.au/cos30045/s101994340/project/sub_prod.js

> Users > owner > Documents > uni > sem 1 2020 > Data Visualisation > project > JS sub_prod.js > subbarChart > on("click") callback

```
function subbarChart()
{

    //define margins, width and height
    var margin = {top: 20, right: 30, bottom: 40, left: 60};
    var w = 1000 - margin.left - margin.right;
    var h = 400 - margin.top - margin.bottom;

    var dataset = subdata;
    //create svg
    var svg = d3.select("#subprod")
    .append("svg")
    .attr("width", w + margin.left + margin.right)
    .attr("height", h + margin.top + margin.bottom)
    .append("g")
    .attr("transform",
            "translate(" + margin.left + "," + margin.top + ")");

    svg.append("text")
            .attr("x", w / 2)
            .attr("y", 0 + margin.top/2)
            .attr("text-anchor", "middle")
            .style("font-size", "20px")
            .style("font-weight", "bold")
            .text("Land Use");

    // X scale and axis
    var x = d3.scaleBand()
        .range([0, w])
        .domain(dataset.map(function(d) { return d.Product; }))
        .padding(0.4);

    svg.append("g")
        .attr("transform", "translate(0," + h + ")")
        .call(d3.axisBottom(x))
        .selectAll("text")
        .attr("class", "xaxis")
        .style("text-anchor", "center")

    //Y scale and axis
    var y = d3.scaleLinear()
        .domain([0, d3.max(dataset, function (d) {
            return d.Land;
        })])
        .range([h, 0]);
```

STACKED LIFECYCLE

https://mercury.swin.edu.au/cos30045/s101994340/project/stacked_lifecycle.js

```
function stackedBar(dataset){
    //set margins, width and height
    var margin = {top: 20, right: 30, bottom: 40, left: 60};
    var w = 950 - margin.left - margin.right;
    var h = 500 - margin.top - margin.bottom;

    //create svg
    var svg = d3.select("#stackedbar")
    .append("svg")
    .attr("width", w + margin.left + margin.right)
    .attr("height", h + margin.top + margin.bottom)
    .append("g")
    .attr("transform",
            "translate(" + margin.left + "," + margin.top + ")");

    //create stack
    var stack = d3.stack()
    .keys(["Land", "Feed", "Farm", "Processing", "Transport", "Packaging", "Retail"]);

    //create series
    var series = stack(dataset);
    //check if loaded properly
    console.log(series);

    //define the color scheme
    var color = d3.scaleOrdinal(["#296584", "#007b91", "#008f88", "#009f6b", "#63ab40", "#afaf02", "#ffa600"]);

    //create rects
    var groups = svg.selectAll("g")
        .data(series)
        .enter()
        .append("g")
        .attr("fill", function (d, i) {
            return color(i);
        });

    console.log(groups)

    //add x axis
    var xScale = d3.scaleBand()
        .range([0, w])
        .domain(dataset.map(function(d) { return d.product; }))
        .padding(0.3)
```

https://mercury.swin.edu.au/cos30045/s101994340/project/style.css