Green Tomatoes: Carbon Footprint of Food

INFO 247: Final Project

Minji Yoo & Ashley O'Neale

Project Goals

We had two primary goals for this project. One was to educate consumers on the relationship between food and climate change, and the second was to encourage consumers to make more eco-friendly food buying choices when shopping at the grocery store. In order to achieve these two overarching goals, we aimed to create a webpage that incorporated data visualizations, storytelling, and imagery to do the following:

- To convey the importance of taking immediate action to reduce carbon emissions.
- To educate people on and allow them to explore how different foods vary in terms of carbon emissions so that they can opt for less carbon-intensive foods going forward.
- To help people feel like they are part of a collective effort to reduce carbon footprint and emphasize impacts on an individual level.
- To convey information in an easy-to-understand, digestible way so that people who don't have extensive background knowledge on the subject can relate and understand.
- To make effective use of both logical arguments based on data as well as emotionally compelling imagery and language to persuade people to change their behavior.
- To convey that making changes to your diet can be good for both the environment and your personal health in terms of nutritional in-take.

Related Work

1. **"Environmental Impacts of Food Production" by Hannah Ritchie and Max Roser (January 2020)**

   Link: https://ourworldindata.org/environmental-impacts-of-food

   Key takeaways:
   - Food has huge environmental impacts

- Reducing GHG emissions from food production will be one of the biggest challenges
- Do you want to reduce the carbon footprint of your food? Focus on what you eat, not whether your food is local
- Scarcity-weighted water footprint provides how each food item contributes freshwater scarcity around the world
- Eutrophication - the pollution of water bodies and ecosystems with excess nutrients - is a major environmental problem
- Whether food travels by sea or air makes all the difference (Food miles)

Impact on our project:
We learned so much about the environmental impact of food from this research. There were a couple of common beliefs that we had, such as eating local, organic, less packaged food would be the main strategy to combat CO2 emissions of food. However, as we looked into CO2 emissions breakdowns of the food life cycle, we realized that what we eat matters the most, and CO2 emissions from transportation and packaging take up an only minute portion.

2. **"Here's the real impact of the food we eat on the environment" by Stephen Clune and Karli Verghese (December 2016)**

   Link:
   https://www.weforum.org/agenda/2016/12/your-kitchen-and-the-planet-the-impact-of-our-food-on-the-environment

   Key takeaways:
   The food we eat is responsible for almost a third of our global carbon footprint. The research ranked fresh foods based on how much greenhouse gas is produced from farm to fork. Red meat is the most emissions-intensive food we consume, but field-grown vegetables produce the least greenhouse gas.

   Impact on our project:
   This research confirmed what we learned from the first source. Although this study focuses on the much narrower scope - food production, we could once again see that red meat is the most emissions-intensive food.

3. **"Environmental Impact of Food Production and Consumption" by Palaniappa Krishnan Bioresources Engineering Department, University of Delaware, USA (2017)**

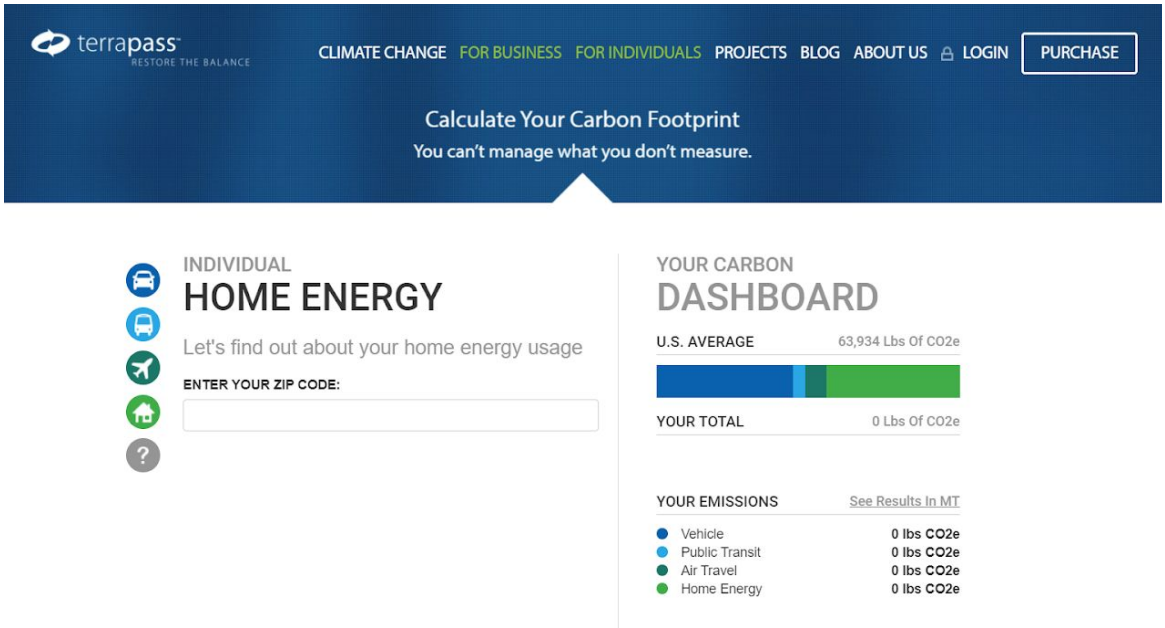
Link: https://www.eolss.net/Sample-Chapters/C07/E5-17-02-03.pdf

Key takeaways:
There are a number of important issues in agricultural food production and consumption that have significant impacts on the environment and human health such as soil biodiversity, desertification, water use and water pollution, energy, climate change, chemicals, food safety and biotechnology.

Impact on our project:
This study broadened our knowledge of the impacts of agricultural food production and consumption on the environment. It didn't have a direct influence on our project but helped us to develop a sense that food production and consumption are important at many levels.

4. **Carbon footprint calculator**

Link: https://www.terrapass.com/carbon-footprint-calculator

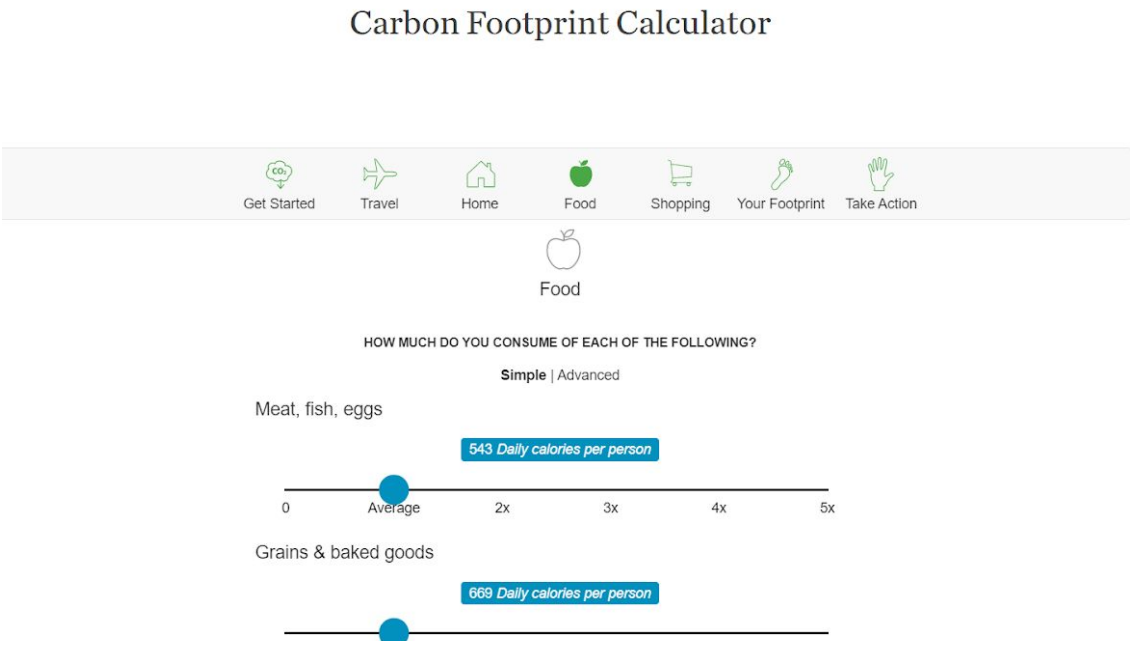


Impact on our project:

One of the applications of our project is to develop a personal evaluation system that is attached to the website. This carbon footprint calculator helped us to design how to interact with users.

5. **Carbon footprint calculator including food category**

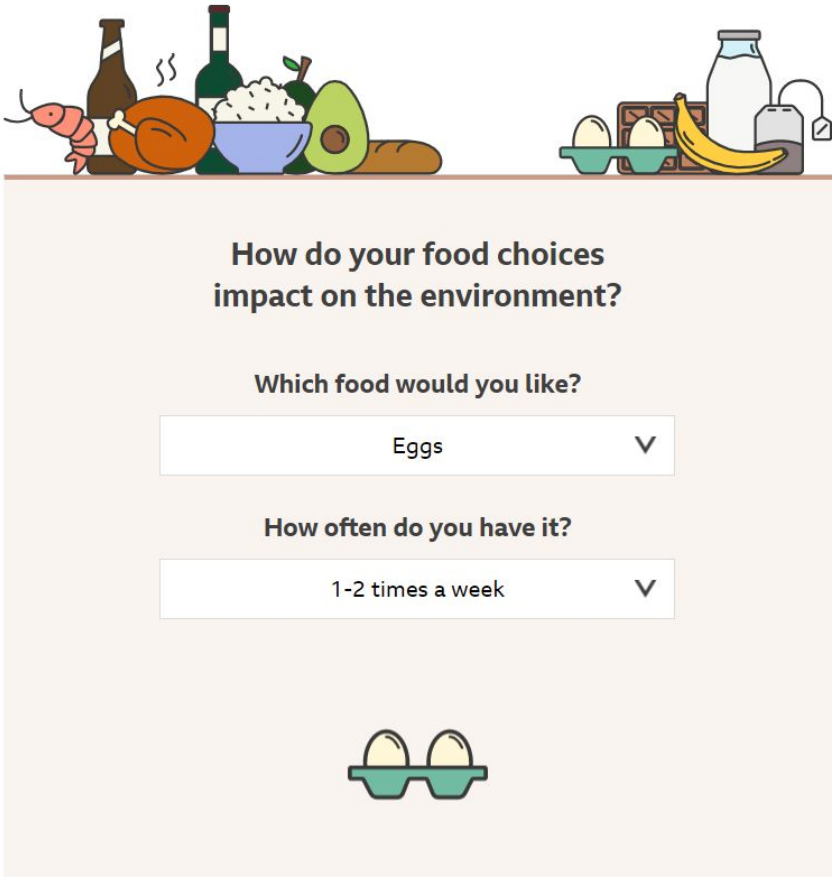
Link:
https://www.nature.org/en-us/get-involved/how-to-help/carbon-footprint-calculator



Impact on our project:
Along with #4, this carbon footprint calculator is also designed to measure CO2 emissions of an individual. While #4 focuses on transportation, #5 considers food and shopping habits. Therefore, we could compare the UI of each calculator and have a chance to think about the granularity of measurement. This calculation also helped us to understand the position of emissions that come from food on the household level and helped us to create a visualization showing that.

6. **Carbon footprint calculator focusing on food consumption**

Link: https://www.bbc.com/news/science-environment-46459714



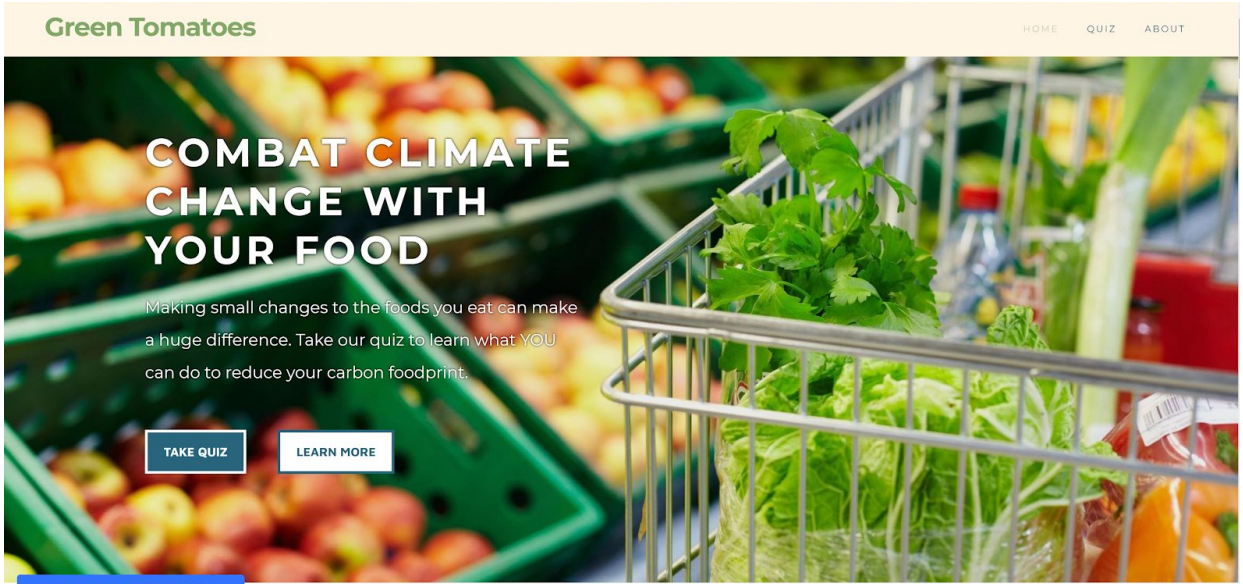
Impact on our project:
This is another carbon footprint calculator available focusing on food choices. Although it doesn't provide an option for a combination of food choices, users can see how each food item affects the environment with an easy to understand visualization.

Visualization Description and Iterations

We created a web page consisting of seven sections, some which include data visualizations and others with just images and text to aid with storytelling. First, we created an initial prototype that was not fully functional and used it to conduct usability testing with three users (P1, P2, & P3). Based on the results of the usability study and feedback we received from users, we iterated on our design to develop the final fully functional version.

Website Link: https://greentomatoesproject.weebly.com/

SECTION 1: COMBAT CLIMATE CHANGE WITH YOUR FOOD



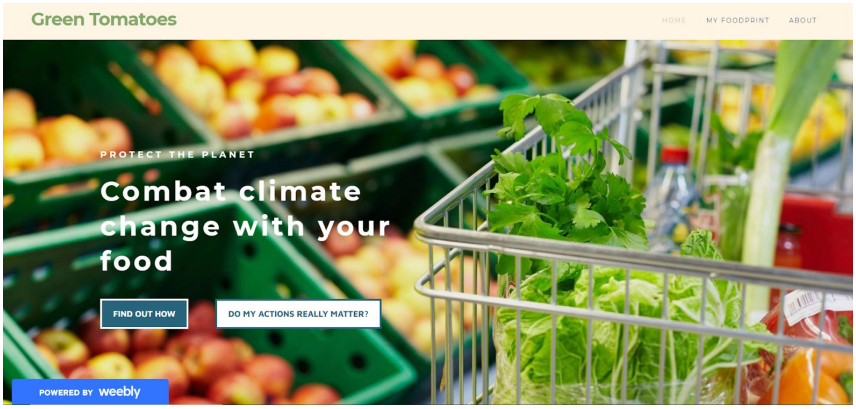
Description

This section is the first thing that users see when visiting the Green Tomatoes website. Through the use of images and text, it conveys our key message that food plays a role in climate change and encourages people to make changes to the foods they eat in order to help combat climate change. This section also invites users to complete a quiz, which although outside the scope of this particular project, is the main feature of the website. The quiz provides users a personalized assessment of the groceries they buy and recommendations on how they can reduce their carbon footprint from food. If users want to learn more about the relationship between climate change and food, they can click “Learn More” or scroll down to see the following sections, which delve into more detail.

Usability Testing

Scenario

Users can see what the website is about and figure out where to click based on what they want to do.



Task/Test Measures

Participants were asked to explain what they see and how they would interact with this section.

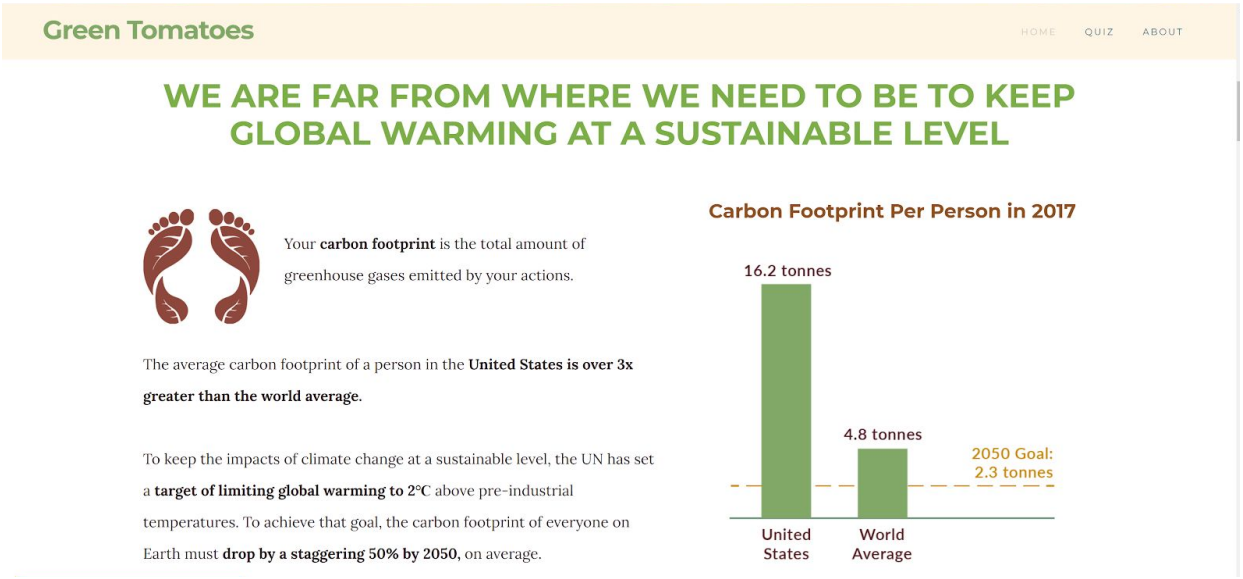
Key Results

- **Positive:** P2 correctly anticipated that “Find out how” would lead to recommendations on what people should/shouldn’t purchase and “Do my action really matter” would lead to more evidence and a data-heavy page.
- **Negative:** P3 didn’t understand what the site is for. P3 first thought the website is about buying organic foods (as the title “Green Tomatoes” indicated) and anticipated “Find out how” would lead to buy organic foods. P3 anticipated “Do my actions really matter” would preach to him about climate changes due to CO2 emissions. P3 also mentioned that the term “Foodprint” is vague.

Interventions

- Changed the button text to be more specific, to clarify the difference between the two buttons, and to help users better anticipate what might happen when clicking on each button.
    - “Find out how” ➔ “Take Quiz”
    - “Do my actions really matter?” ➔ “Learn More”
- Added a subtitle to clarify the purpose of the website and highlight the quiz as a main feature of the site.

SECTION 2: WE ARE FAR FROM WHERE WE NEED TO BE TO KEEP GLOBAL WARMING AT A SUSTAINABLE LEVEL



Description

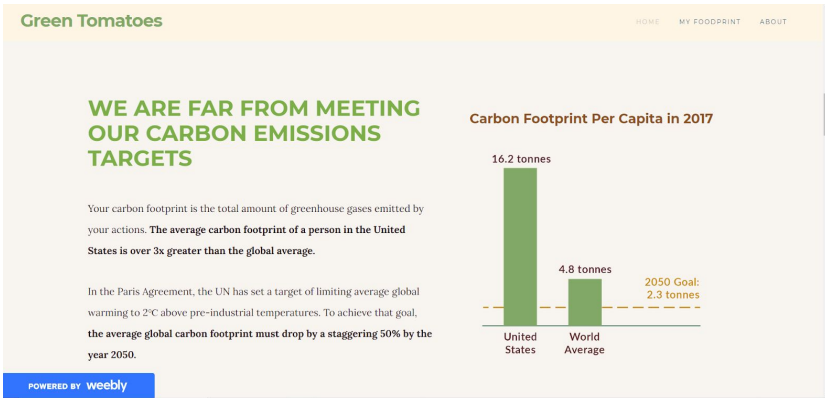
This section uses a combination of text, icons, and data visualization to convey to users that we are far where we need to be to keep global warming at a sustainable level. The bar graph emphasizes the huge difference between the average carbon footprint of a person in the United States and the global average. It also highlights the large gap between where we are now and where we need to be in order to successfully meet our goal of limiting global warming to under 2°C. Our main intention for this section was to stress the importance and urgency of taking action to reduce your carbon footprint.

To ensure that people who are not familiar with terms such as “carbon footprint” are still able to follow the narrative, we included a definition of carbon footprint in the text and paired it with an icon to help convey that meaning. We also chose to label the graph as “Carbon Footprint *Per Person*” instead of “Carbon Footprint *Per Capita*” to avoid using technical language.

Usability Testing

Scenario

Users feel the urgency of carbon emissions reduction and have a sense of crisis.



Tasks/Test Measures

Participants were asked to explain what they see and how they would interact with this section.

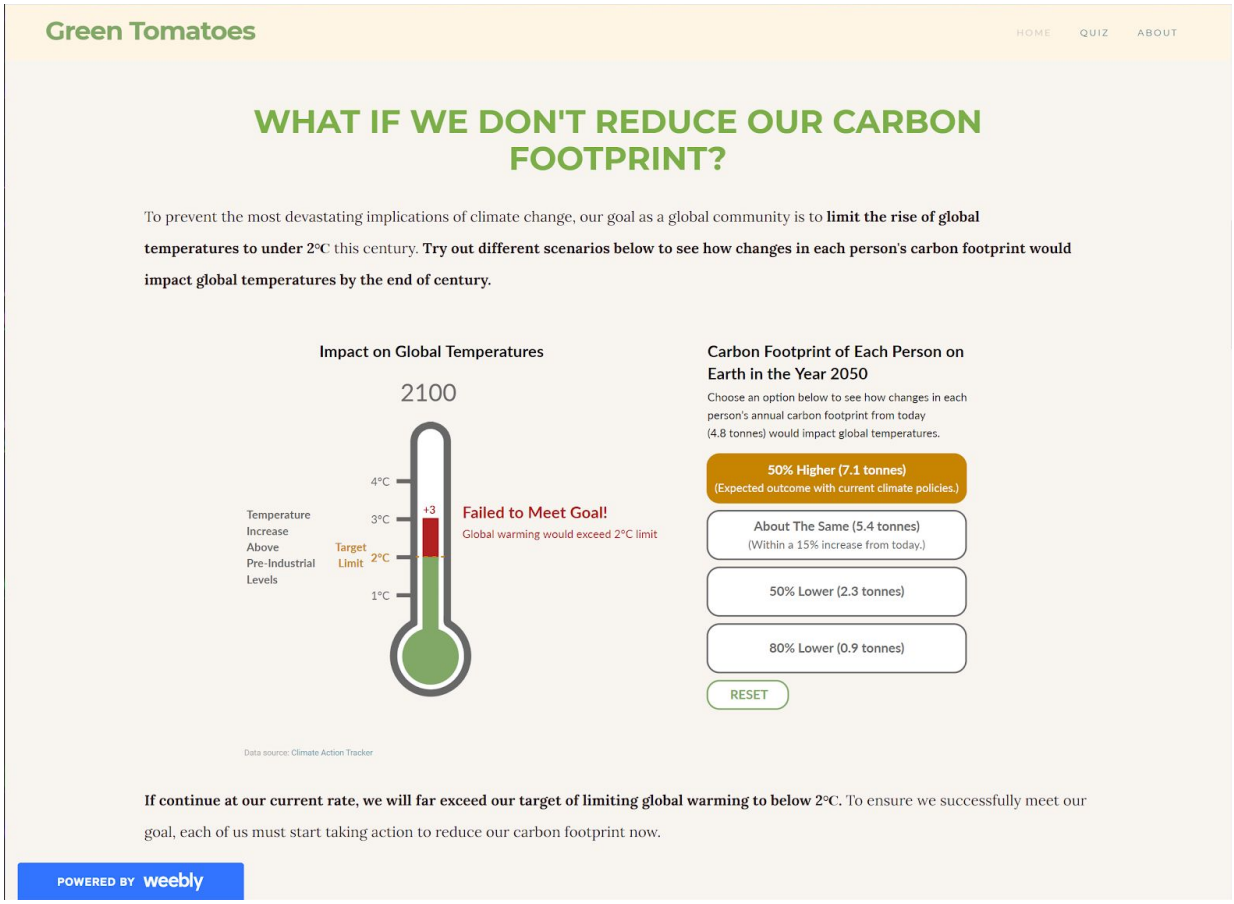
Key Results

- **Positive:** P2 thought the fact that the US is doing bad is really emphasized here, but the goal seems unachievable and somewhat depressing.
- **Negative:** P1's only takeaway was that people in the US tend to have bigger carbon footprints than people in other countries, but the other important intended takeaway was that we are far from where we need to be emissions-wise to meet our goal of keeping temperatures from rising above 2°C. P3 didn't like the text-heavy page and suggested making the graph self-explanatory.

Interventions

- Added an icon for "carbon footprint" to help convey some of the information included in the text
- Moved this section from the 3rd position on the website to the 2nd in order to improve the flow of storytelling based on overall feedback from P2. She had suggested starting broad talking about global warming in general and narrowing down later to the carbon impacts of food specifically.

SECTION 3: WHAT IF WE DON'T REDUCE OUR CARBON FOOTPRINT?



Description

This section includes an interactive visualization showing different scenarios for how changes in each person's carbon footprint would impact global temperatures. We wanted to demonstrate to users that their individual carbon footprint does matter and provide further evidence for the claim we made in the previous section that we would all have to reduce our carbon footprint significantly in order to meet our goal of limiting global temperatures to below 2°C. As with the previous section, our intention here was to stress the importance and urgency of taking immediate action to reduce your carbon footprint and to emphasize that not meeting our emissions targets is a likely and real possibility if we continue as we are now.

The visualization includes a thermometer on the left side that shows the global temperature increase above pre-industrial levels. As of today, global temperatures have already risen by an average of 1.1°C above pre-industrial levels. To see projections for how much the temperature would rise by the end of the century under different carbon

emission scenarios, users can click on one of the four buttons on the right. The first button corresponds to the scenario in which the annual carbon footprint of per person on Earth increases by 50% by the year 2050, which is the expected outcome based on current climate policies. The second button corresponds to the scenario in which the carbon footprint per person remains about the same as today. The data used for this visualization did not include data for if the carbon footprint is exactly the same as today, so we used the closest data point we could find, which was within 15% of today's value. The third button corresponds to the scenario in which the carbon footprint drops by 50%, which is the same amount mentioned in the previous section. Finally, the fourth button corresponds to the scenario in which each person's carbon footprint drops by 80%, which would be the most ideal scenario. When users click on one of these buttons, the mercury in the thermometer gradually rises and the year above the thermometer increases from 2017 to 2100. When it gets to 2100, the animation stops and text appears indicating whether or not we would be successful at achieving our goal of limiting global warming to less than 2°C in that scenario. If the temperature stays below 2°C, green text appears indicating we are successful and the mercury in the thermometer remains the color green. However, if the temperature rises above 2°C, red text appears indicating that we failed to reach our goal and the mercury for the portion above the 2°C limit turns red as well. Users can then click on another button to run a different scenario or reset the thermometer back to 2017 by clicking on the Reset button.

The data that was used for this visualization did not include the average annual carbon footprint per person but rather the total annual global carbon footprint. Therefore, we had to calculate the average carbon footprint per person values that are included in the visualization by dividing the total global amount by the projected population in 2050, which is 8.2 billion people.

Code: https://observablehq.com/@aoneale/temperature-change

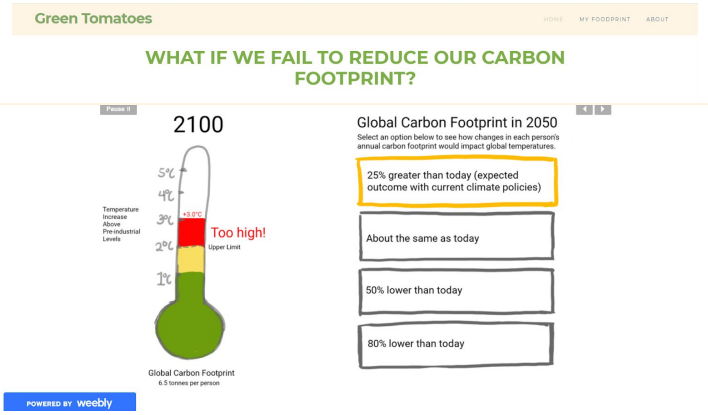
Usability Testing

Scenario

Users understand how change / no change of current behavior would contribute to global warming.

Tasks/Test Measures

Participants were asked to explain what they see and how they would interact with this visualization.



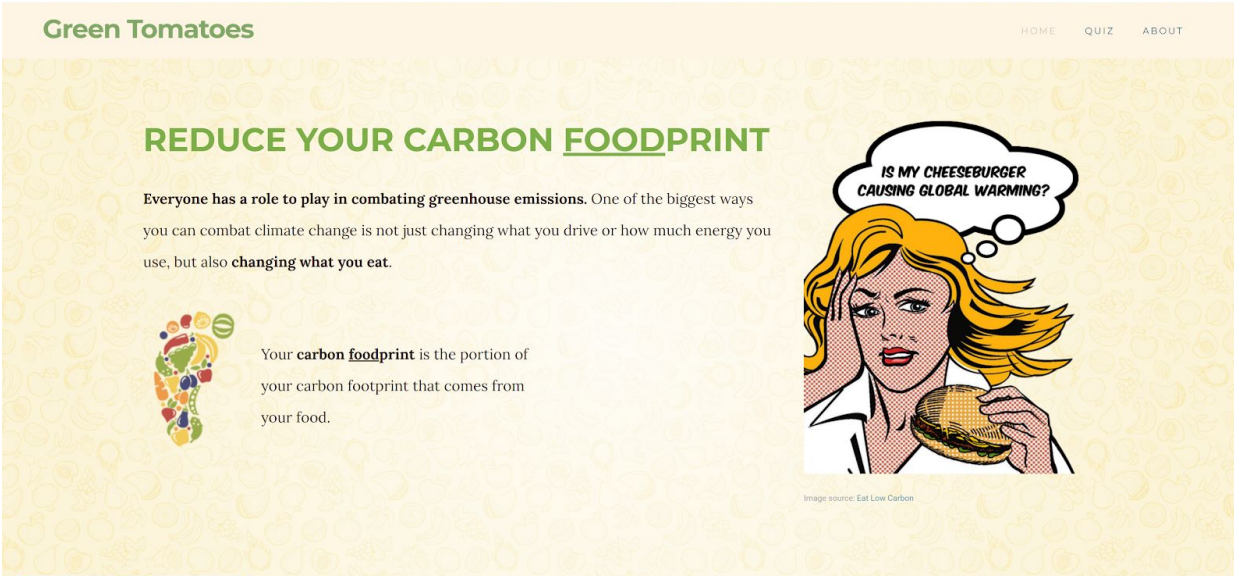
Key Results

- **Positive:** P2 and P3 mentioned the thermometer is cool in terms of visualization.
- **Negative:** P1 didn't immediately realize that the focus was only on global temperature increase rather than general effects of not reducing carbon footprint. P1 wasn't entirely sure what "too high" meant other than it was bad, commenting, "Too high for what?". P2 took some time to understand the graphic, as she wasn't sure about how to interpret the thermometer. Additionally, P2 tried to reconcile 1-3 °C changes and the goal given above and was confused about the relationship between carbon footprint in 2050 and thermometer in 2100. P3 also wasn't entirely sure how to interpret the thermometer.

Interventions

- Changed text to better clarify and explain the result
    - "Too high" ➜ "Failed to Meet Goal! Global warming would exceed 2°C limit"
- Added an additional title above the thermometer to clarify what it is supposed to be showing:
    - Title: "Impact on Global Temperatures"
- Removed the yellow mercury color from the thermometer to simplify the visualization and make it easier to interpret
- Added the exact carbon footprint amount per person to each button in addition to the percent change to help users understand what the percentage is referring to so that they wouldn't have to manually reconcile against the graph in the previous section as P2 did in the usability test

SECTION 4: REDUCE YOUR CARBON FOODPRINT

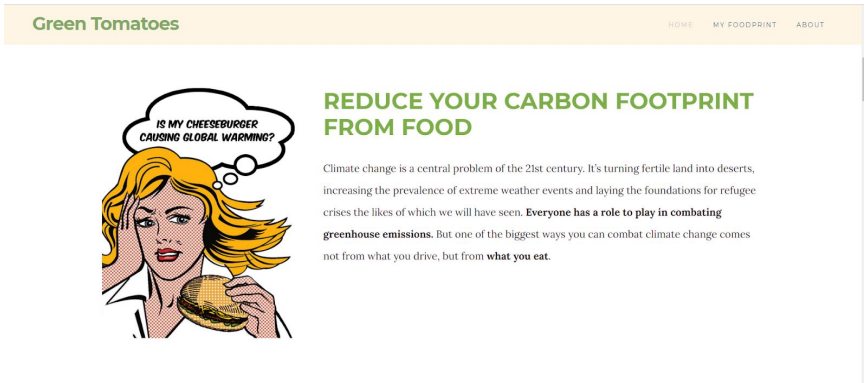


Description

This section serves as a transition between the broader discussion of global warming and the importance of reducing our overall carbon footprint to a narrower discussion about carbon emissions from food and reducing our carbon footprint from food specifically. It includes text and imagery to support the flow of the overall narrative and to convey that a meaningful way to reduce your carbon footprint is to change the foods that you eat. This section introduces and defines the term “carbon foodprint,” which is the portion of your carbon footprint that comes from food. Similar to when we defined carbon footprint in section 2, we included an image here to help users process and understand the written definition. An image of a woman wondering if her cheeseburger is causing global warming is included to help convey the association between food and climate change and to serve as a memorable image to help users remember this information.

Usability Testing

Scenario
Users get the idea that they need to do something about CO2 emissions, and they can do so by considering what they eat.



Tasks/Test Measures

Participants were asked to explain what they see and how they would interact with this section.

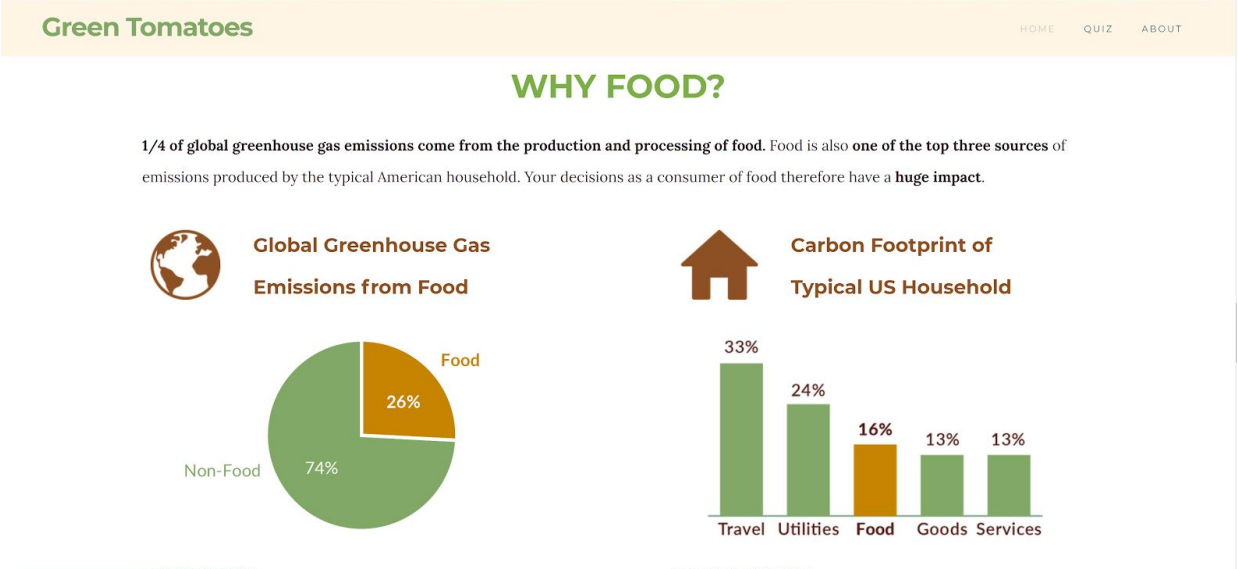
Key Results

- **Positive:** For P1, the image of a woman wondering if her cheeseburger is causing global warming was effective at getting her to think that meat, in particular, might have an impact. P2/P3 also liked the cartoon and the message that everyone can participate. P2 mentioned that the page makes her want to learn more.
- **Negative:** P2 was confused about the refugee crisis, so she suggested a link to an article may be helpful to understand. P3 mentioned that the paragraph is not written efficiently. He suggested changing the order of sentences.

Interventions

- Changed the title to incorporate the term “carbon foodprint” based on general feedback from P2 that it was previously being used consistently throughout the web page and that being more consistent may help with user understanding.
    - Title: “Reduce your carbon footprint from food” ➜ “Reduce your carbon foodprint”
- Changed the paragraph text
    - Added a definition of carbon foodprint since this term is not commonly used and is likely unfamiliar to users
    - Removed the part mentioning refugees since we didn’t necessarily have a specific source to confirm this information and may have been distracting users the our primary narrative
- Moved this section from 2nd position to the 4th position. Originally, it was intended to introduce the overall narrative, but based on feedback from P2 that the storytelling flow was a bit disconnected, we instead made it a transition between global warming in general and the carbon impacts of food specifically.

SECTION 5: WHY FOOD?



Description

We imagine that users have likely heard a decent amount about conserving energy or driving less as ways to reduce their carbon footprint but have heard less about doing so by changing the foods they eat. Therefore, the motivation for this section was to explain why food is also an important element in the fight against climate change.

As shown in the pie chart on the left, 26% of global carbon emissions come from food. Although pie charts have many drawbacks, it seemed appropriate in this case since there are only two categories shown and it is not hard to tell visually that food takes up about ¼ of the circle. Also, we expected that users would be familiar with pie charts and know how to read them easily. These assumptions were supported by our observations during the usability test.

The bar graph on the right shows that food is one of the top three sources of greenhouse gas emissions produced by the typical American household. To make the narrative relatable to an individual person and support the premise that fighting climate change requires action on the individual level, not just the organizational or societal level, we thought it was important to present data on an individual level whenever possible. However, in this case, we did not have data indicating the carbon footprint breakdown per person, so we instead chose to use the closest unit we could find, which was per household.

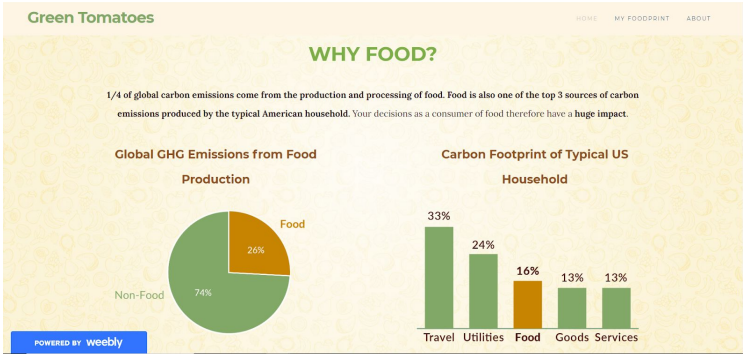
In both visualizations, we decided to highlight food in a different color since that is the main information we wanted to convey. We used the same colors to represent food and

non-food in both charts to be consistent and help users to recognize and understand our key points better.

Usability Testing

Scenario

User understands food takes up an important portion in terms of CO2 emissions.



Tasks/Test Measures

Participants were asked to explain what they see and how they would interact with this page.

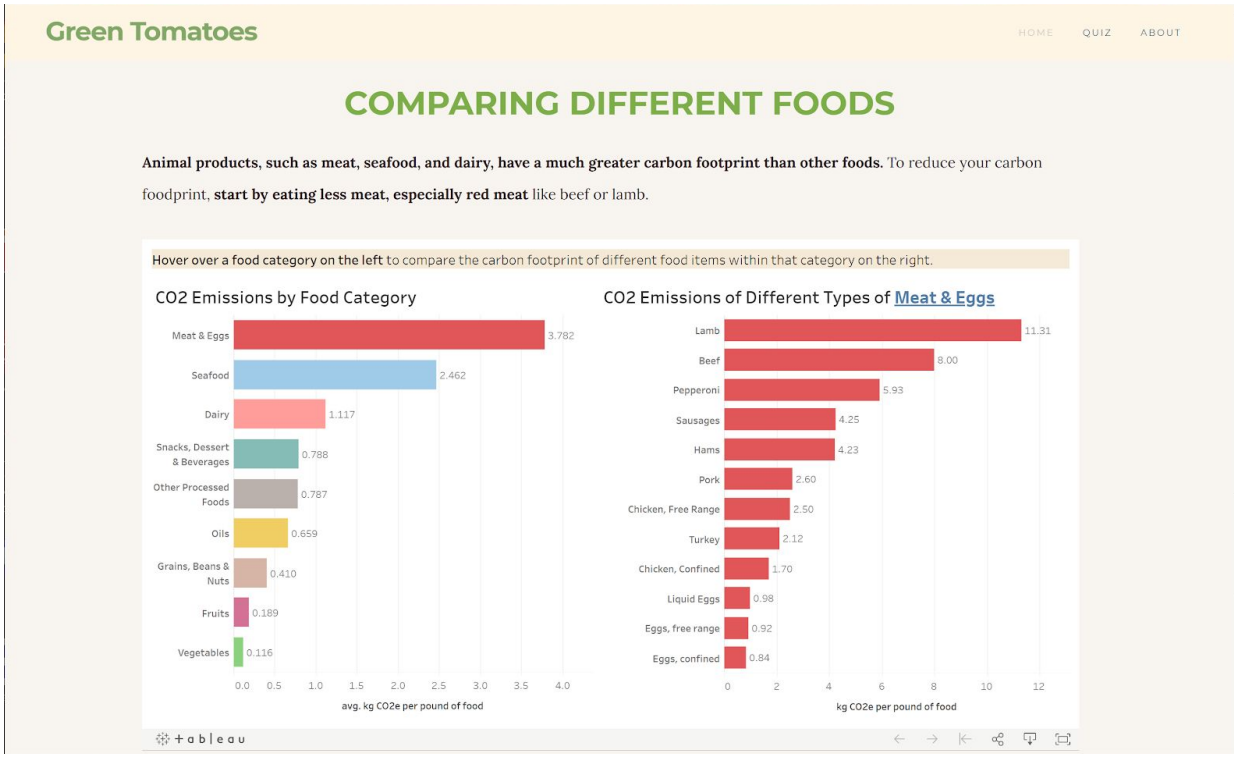
Key Results

- **Positive:** P1 was able to easily understand both charts, especially the pie chart.
- **Negative:** P2 was confused with 26% on the pie chart and 16% on the bar chart. P3 didn't understand that the bar chart emphasizes the importance of CO2 from food. (He mentioned that it seems like we need to tackle down travel first since it takes up 33%.) He didn't get what GHG means and why the title of the pie chart is Global GHG Emissions from Food Production instead of GHG Emission.

Interventions

- Added icons to help emphasize that the two charts are showing the breakdown on two different levels of granularity, which is why the amounts are different.
- Changed title of pie chart for clarity
  - "Global GHG Emissions from Food Production" ➜ "Global Greenhouse Gas Emissions from Food"

SECTION 6: COMPARING DIFFERENT FOODS



Description

This section includes an interactive visualization that enables users to explore and compare the carbon emissions of different types of foods. In doing so, users can identify foods that produce high amounts of greenhouse gas emissions and find alternatives within the same category that produce less emissions. For example, the production and processing of beef and lamb produces a very large amount of carbon emissions, but other meats, such as chicken or turkey, produce significantly less emissions. Therefore, with this visualization, users can see, for example, that if they want to eat meat, they can reduce their carbon foodprint by substituting red meat for poultry.

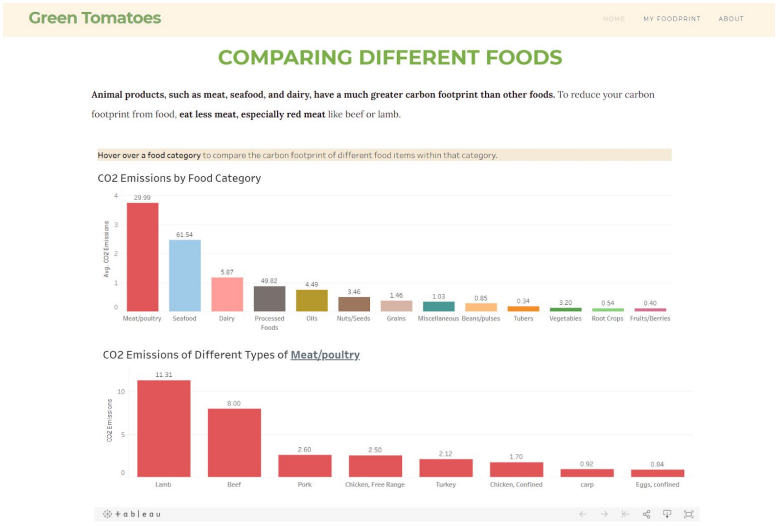
The bar chart on the left displays the average CO2 emissions per pound for various categories of food, such as Meat & Eggs, Seafood, Fruits, etc. It is ordered in descending order from greatest to lowest emissions. Looking at this graph, users can see that animal products, especially meat, produce much more carbon emissions than other types of food. Each category is represented in a different color, and as much as possible, we tried to assign colors that would match the given category (e.g. Meat=Red, Seafood=Blue, Vegetables= Green, etc.). Users can drill down into each of these categories by hovering over the corresponding bar, which filters the category of food items shown on the left. The chart on the left shows the CO2 emissions per pound for various food items within

the selected category. The title above the graph on the left is dynamic and changes depending on the food category that the user currently has selected.

Usability Testing

Scenario

Users can interact with the visualization to learn about how CO2 emissions are different across the food category.



Tasks/Test Measures

Asked users to perform the following tasks:

T1: Find the average CO2 emissions of dairy
T2: Find the average CO2 emissions of seafood
T3: Find which types of meat have the lowest and greatest emissions
T4: Find which types of grains have the lowest and greatest emissions

We took note of whether their answers were correct and how long they took to complete each task.

Results

Tasks \ Participants	**P1**	**P2**	**P3**
T1	12 sec. (Wrong)	8 sec. (Wrong)	20 sec. (Wrong)
T2	9 sec. (Wrong)	15 sec. (Correct)	5 sec. (Wrong)
T3	29 sec. (Partially correct)	10 sec. (Correct)	9 sec. (Correct)
T4	50 sec. (Correct)	5 sec. (Correct)	10 sec. (Correct)

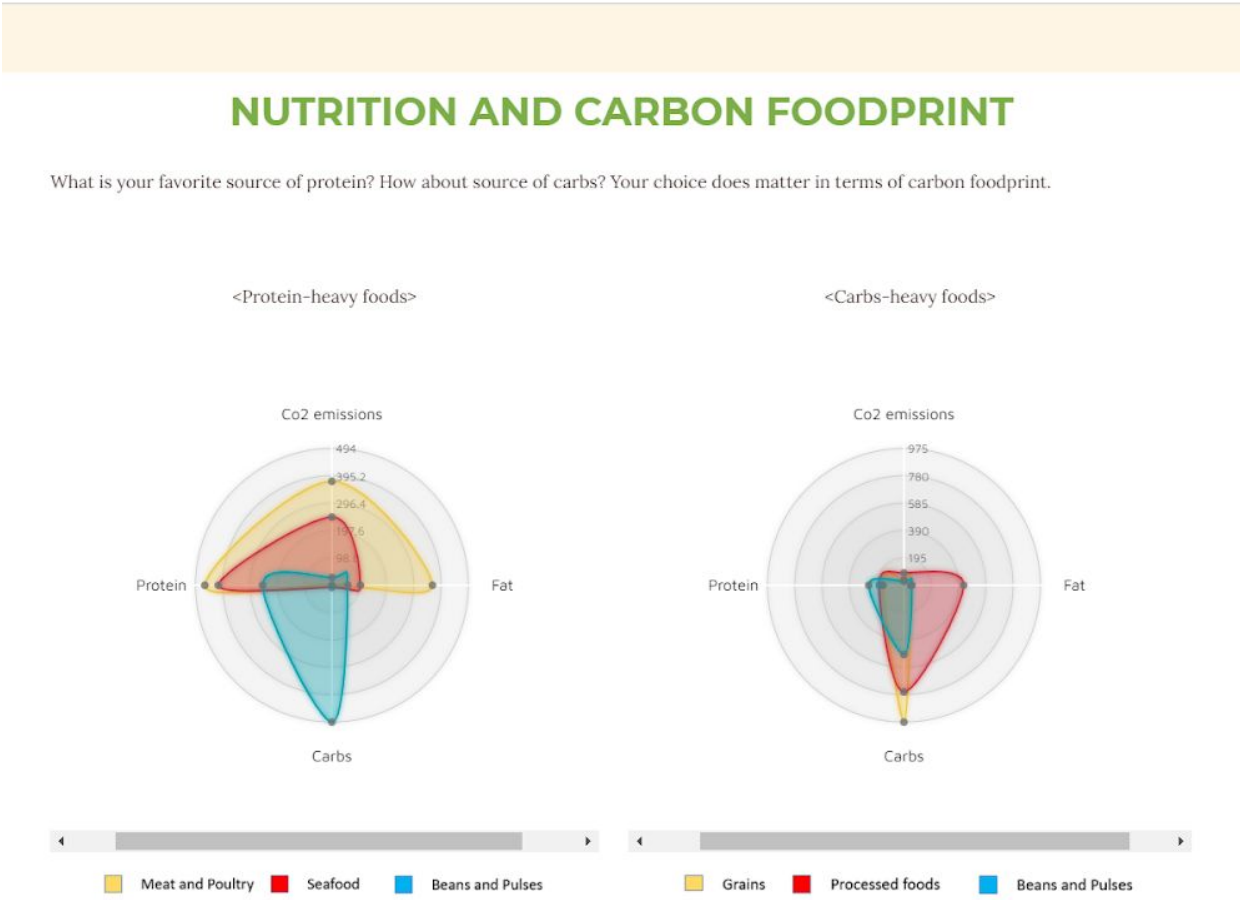
- **Positive:** P2: User was able to learn about new things like ‘free-range’ chicken has more CO2 emission than “caged” chicken.

- **Negative:**
    - The tooltips confused P1. P1 thought that the hover action mentioned in the instruction was the tooltip and didn't even notice the chart at the bottom.
    - P1 provided incorrect amounts for average CO2 emissions. She looked only at the tooltip but not the actual measures of the bars. For some reason, the values on the tooltip conflict with the measures of the bars.
    - (P1/P2/P3) Carp is seafood but is mistakenly coded as meat. Also, even though eggs are included under the meat category, the P1 did not consider eggs as meat, so she did not say “eggs” as the answer for which meat has the lowest emissions.
    - Even though the user clicked on grains, for some reason, the viz showed vegetables instead.
    - P2 said It would be better not to change the scale of the y axis in the bottom chart since it is misleading.
    - P2/P3 noticed that labels in the top chart are not the average but the accumulated sum.
    - P3 thinks that it doesn’t explain why certain food categories emit more CO2.

Interventions

- Fixed tooltip and labels on bars so that all the amounts are matching, and for the CO2 Emissions Per Category graph, ensured everything is showing the average emissions, not the sum.
- Reclassified categories to be more understandable and fixed miscoded data
- Added unit of carbon emissions and specified that it’s emissions per pound of food
- Changed layout from horizontal to vertical so that it’s easier to read labels and so that the CO2 Emissions for Different Types of <Category> chart would be less likely to go unnoticed if the user doesn’t scroll down.

SECTION 7: NUTRITION AND CARBON FOODPRINT



Description

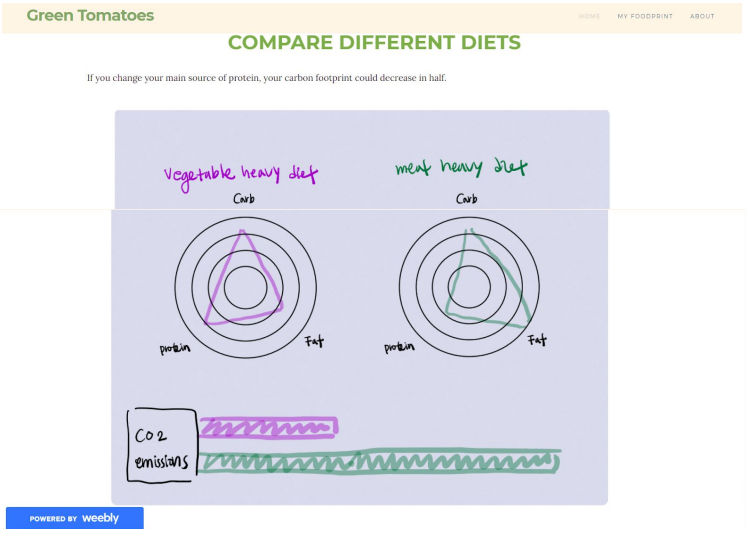
This section includes an interactive visualization that enables users to explore and compare the carbon emissions and nutrition facts of protein-heavy foods and carbs-heavy foods. We picked 3 food categories - Meat & Poultry, Seafood, and Beans & Pulses - as protein-heavy foods, and also picked Grains, Processed foods, and Beans and Pulses as carbs-heavy foods. By hovering over the radar charts, users can see exact figures of each highlighted food category. The main takeaway from the radar charts is that if users switch their choice of protein and carbs, they can still get an adequate amount of nutrition while also significantly reducing their carbon foodprint.

Code: https://observablehq.com/@minji-yoo/radar-chart

Usability Testing

Scenario

Users can understand that a vegetable heavy diet decreases CO2 emissions and is also nutritious. (People can still intake enough protein.)



Task/Test Measures

Participants were asked to explain what they see and how they would interact with this visualization.

Key Results

- **Positive:** P2 thought the spider chart is cool.
- **Negative:**
    - P1 didn't understand the diagrams. She wasn't sure what the triangles and circles meant and didn't know how to interact with them.
    - P3 said it is hard to interpret the chart since he can't see the whole picture at once.
    - P3 suggested changing the order of spider charts so that they can convey the message "switching from meat-heavy to vegetable-heavy".

Interventions

- Made radar charts interactive so that users can see exact figures when they hover on each graph.
- Added CO2 emissions to the radar chart axis so that the comparison is easier for users to see.
- Rather than comparing a vegetable-heavy diet with a meat-heavy diet, which are vague, we made a comparison among the top three sources of protein/carbs.

- Color-coded each food category and highlight them when users hover on each food category.

Data

Description of Original Data	Where It Was Used	Source
Per capita CO2 emissions - By country, includes world average - Years: 1800 -2017	Section 2: We Are Far From Where We Need To Be To Keep Global Warming At A Sustainable Level	Website: Our World in Data
Global Emissions Time Series For Different Scenarios - Historical and projected annual global carbon emissions (1990-2100) - Temperature estimates for 2100	Section 3: What If We Don't Reduce Our Carbon Footprint?	Website: Climate Action Tracker
Global greenhouse gas emissions from food production - Breakdown of how much global emissions comes from food production	Section 5: Why Food? (Global Greenhouse Gas Emissions from Food)	Website: Our World in Data
Carbon Footprint Calculator - Breakdown of carbon footprint of household with average criteria	Section 5: Why Food? (Carbon Footprint of Typical US Household)	Website: The Nature Conservancy
Co2 emissions from food by food items - US Life-Cycle Inventory Database - IPCC Guidelines for National Greenhouse Gas Inventories	Section 6: Comparing Different Foods Section 7: Nutrition And Carbon Foodprint	Website: Foodemissions.com
Nutrition facts data by food	Section 7: Nutrition And Carbon	Website:

items	Foodprint	https://www.nutritionvalue.org/

Tools

- **D3 & Observable** - To create the following interactive visualizations:
    - Section 3: What If We Don't Reduce Our Carbon Footprint?
    - Section 7: Nutrition And Carbon Foodprint
- **Tableau** - To conduct exploratory data analysis and create the following interactive visualization:
    - Section 6: Comparing Different Foods
- **Illustrator** - To create imagery/iconography that helps convey our message and create static data visualizations for the following sections:
    - Section 2: We Are Far From Where We Need To Be To Keep Global Warming At A Sustainable Level
    - Section 5: Why Food?
- **Weebly** - To create a web page and embed the visualizations created in Tableau and D3

Division of Work

Project Component	Sub Component	Weight	Minji	Ashley
Literature Review	---	1	**90%**	**10%**
Data Preparation	Data Sourcing	1	**70%**	**30%**
	Dataset Merging	1	**100%**	**0%**
	Data Preprocessing	1	**100%**	**0%**
	EDA	1	**50%**	**50%**
Visualization / Design	Section 1: Combat Climate Change With Your Food	0.3	**0%**	**100%**
	Section 2: We Are Far From Where We Need To Be To Keep	1	**0%**	**100%**

	Global Warming At A Sustainable Level			
	Section 3: What If We Don't Reduce Our Carbon Footprint?	1	**0%**	**100%**
	Section 4: Reduce Your Carbon Foodprint	0.3	**0%**	**100%**
	Section 5: Why Food?	1	**0%**	**100%**
	Section 6: Comparing Different Foods	1	**0%**	**100%**
	Section 7: Nutrition And Carbon Foodprint	1	**100%**	**0%**
User Testing and Others	User Testing	1	**70%**	**30%**
	Report Writing	1	**50%**	**50%**
Weighted Average			**50%**	**50%**