Green Tomatoes

Nudging Consumers Toward More Eco-Conscious Grocery Shopping Habits

Team Members

John Baldwin
Melrose Huang
Ashley O'Neale
Minji Yoo

Faculty Advisor

Dr. Jenna Burrell

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Acknowledgments

Abstract

Global climate change is imminent and largely caused by carbon emissions, a quarter of which may be attributed to the agricultural industry. Although the average consumer may lack control over the practices of an entire industry, they can enact change through what they eat. Plant-based diets, for instance, have a much smaller carbon footprint relative to meat-based diets. By swapping carbon-intensive foods for more environmentally friendly alternatives, consumers can shift market demand and thereby influence underlying large-scale industrial processes. Millennials, in particular, exhibit great potential as changemakers. Extant research suggests that millennials are much more likely, relative to older generations, to believe in climate change and factor in environmental considerations when grocery shopping. Moreover, millennials currently make up the majority of the workforce in the U.S. and therefore have tremendous buying power. Based on insights gathered from user interviews, concept testing, and usability testing, we developed Green Tomatoes, a web platform featuring: (1) a quiz that could assess users' grocery shopping habits and provide potentially actionable insights and (2) several data visualizations intended to inform users on the relationship between food and climate change. Through Green Tomatoes, we hope to empower consumers to make conscious and informed food choices at the grocery store.

Background & Problem Space

The agro-industrial complex is detrimental to the environment in a number of ways. By promoting monoculture, in which farmers only grow or raise one specific plant or animal at a time, the biodiversity of various soil organisms is greatly reduced, which can upend natural ecological processes that lend to efficient carbon sequestration, water storage, and nutrient recycling in soil. Further, agricultural production and processing require the use of large amounts of water[1]. Agriculture is also one of the leading causes of lower water quality, largely due to agricultural runoff that may contain pesticides, fertilizers, and bacteria from animal waste, etc.[2]

Notably, the agricultural sector is a leading contributor to global carbon emissions. In fact, studies suggest that it accounts for roughly a quarter of total emissions[3], only falling behind that of the electricity and heating industry[4]. While most components of large-scale food systems are controlled by corporate actors, the average consumer can exercise a great amount of discretion when grocery shopping. By voting with their dollar, consumers can gradually move the needle: shifting consumer behaviors and public opinions on processed foods and unnatural ingredients, for instance, have already motivated retailers to create more room for healthier and natural alternatives[5].

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[1] Krishnan, P. (2009). Environmental impact of food production and consumption. Future Challenges of Providing High-Quality Water-Volume II, 170. https://www.eolss.net/Sample-Chapters/C07/E5-17-02-03.pdf
[2] "Protecting Water Quality from Agricultural Runoff," United States Environmental Protection Agency, Last modified March 2005, https://www.epa.gov/sites/production/files/2015-09/documents/ag_runoff_fact_sheet.pdf
[3] Hannah Ritchie and Max Roser. "Environmental impacts of food production," Our World in Data, Accessed February 25, 2020, https://ourworldindata.org/environmental-impacts-of-food
[4] "Global Greenhouse Gas Emissions Data," United States Environmental Protection Agency, Accessed February 25, 2020, https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data
[5] Helena Bottemiller Evich, "The End of Big Food," Politico, October 10, 2019, https://www.politico.com/news/2019/10/10/food-industry-consumer-brands-association-043892

Certain food purchases have disproportionately negative environmental consequences. In tandem, animal husbandry, aquaculture, and livestock-related land use comprise over 50% of carbon emissions resulting from food production. In contrast, agronomy--the cultivation of plants for human consumption--and crop-related land use constitute under 30% of food production-based emissions[6]. The gap between various animal products and byproducts is similarly vast. Beef's carbon footprint of 26.61 kilograms of carbon dioxide-equivalent per kilogram (kg CO_2 -eq / kg), for example, stands in stark contrast to that of chicken and field-grown vegetables, which are 3.65 kg CO_2 -eq / kg and 0.37 kg CO_2 -eq / kg, respectively[7]. The magnitude of ruminant animal (i.e., beef and lamb) products' impact on carbon emissions is especially great. Accordingly, consuming non-ruminant animal products and plant-based products as alternatives has the potential to result in substantive and positive changes to one's carbon footprint.

User Research & Design Process

Initial Product Idea

Originally, we conceived of building a rating system, Green Tomatoes, which would measure the environmental impact of businesses by considering the entirety of companies' business models, processes, and marketing campaigns. This metric was intended to level the information

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[6] Hannah Ritchie and Max Roser. "Environmental impacts of food production," Our World in Data, Accessed February 25, 2020, https://ourworldindata.org/environmental-impacts-of-food
[7] Stephen Clune and Karli Verghese, "Millennials drive big growth in sustainable products," World Economic Forum, December 12, 2016, https://www.weforum.org/agenda/2016/12/your-kitchen-and-the-planet-the-impact-of-our-food-on-the-environment

asymmetry between consumers and businesses, as companies typically have little incentive to monitor and publicly share the effects of their practices on the environment. Affording greater transparency to this information would ostensibly nudge companies to adopt thoroughgoing changes in their operations that are more eco-conscious while increasing public awareness and equipping consumers with the knowledge necessary to make more environmentally-friendly decisions. Moreover, investors could potentially leverage the platform as a means of discovering new and environmentally progressive businesses to support.

Desk Research & Pivot

However, our team encountered a number of issues while exploring our initial product idea: namely, there is a lack of publicly accessible data that assesses business practices holistically across a wide range of companies. While we also considered utilizing corporate responsibility survey results as a potential data source, this strategy would have involved contacting individual companies and standardizing measures across a number of different survey tools. At the same time, we questioned whether using entire business models as our unit of evaluation was practical and/or user-friendly. On a similar note, we wondered whether targeting all consumers as our user base was pragmatic.

Through desk research, we found that millennials comprise the largest percentage of the current workforce in the United States and are responsible for $1 trillion in consumer spending per year. On top of holding immense buying power, millennials are also the generation most receptive to the notion of climate change. A recent Gallup poll found that over two-thirds of Americans between the ages of 18 and 29 believe that "global warming is a real, man-made and serious

threat." In contrast, less than half of those between 30 and 49 years of age held the same

sentiment[8]. We also discovered that while approximately three-fourths of millennials claim to be

changing their food buying habits with regard to environmental considerations, only about

one-third of baby boomers are doing the same. This significant divide in sustainable food

consumerism may be explained--in part by the former generation's willingness to spend more

and place a premium on environmentally and socially sustainable items--as well as the latter

generation's propensity toward brand loyalty. The chasm between millennials and baby boomers

may be further exacerbated by the digital divide, as "sustainable shoppers in the U.S. are 67

percent more likely to be digitally engaged."[9]

In light of these statistics, we decided to narrow our target audience down to millennial

consumers. This decision facilitated our user research plan, because we--as individuals

identifying as millennials--could readily access fellow members of our generational group. More

importantly, shifting our focus to the generation with the greatest spending power and interest in

sustainable food consumerism would theoretically magnify the impact of our platform.

User Interviews

At the outset of the project, our initial assumptions were as follows:

1. In general, people want to do things that are better for the environment.

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[8] Jennifer Robison, "Millennials Worry About the Environment -- Should Your Company?," Gallup, May 29, 2019, https://www.gallup.com/workplace/257786/millennials-worry-environment-company.aspx

[9] Caitlin Mullen, "Millennials drive big growth in sustainable products," Bizwomen, December 28, 2018, https://www.bizjournals.com/bizwomen/news/latest-news/2018/12/millennials-drive-big-growth-in-sustainable.html?page=all

2. However, they desire convenience. Consumers also seek to strike a balance between making environmentally-friendly decisions and their own limitations (e.g., financial budgets).

3. Barriers to making eco-conscious choices include lack of money and time/energy. Further, a lack of knowledge may stem from difficulty accessing information from disparate sources.

We accordingly tested these assumptions through remote, semi-structured user interviews (see Appendix A for interview guide). We opted for user interviews, because we were still in the early stages of fleshing out our product concept. As such, we required a method that would provide us with a range of user perspectives from which we could identify common needs and pain points.[10] A semi-structured format enabled us to follow a standard set of questions that directly mapped onto our assumptions and other areas of interest. At the same time, it granted us the flexibility to revise the order of questions to suit the organic flow of conversation and affording the latitude to ask follow-up questions on an ad-hoc basis[11]. Conducting our interviews remotely through phone and/or conference calls also allowed us to gather data from a diverse array of users who were not geographically limited to the San Francisco Bay Area. Since the Bay Area's median household income is almost twice that of the rest of the U.S.[12], solely interfacing with local users could have biased our data and led us to develop a platform tailored toward more affluent users.

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[10] Kathy Baxter, Catherine Courage, and Kelly Caine, Understanding Your Users: A Practical Guide to User Research Methods (New York: Penguin Books, 2009), 100.
[11] Kathy Baxter, Catherine Courage, and Kelly Caine, Understanding Your Users: A Practical Guide to User Research Methods (New York: Penguin Books, 2009), 223.
[12] Leanna Garfield, "Striking maps reveal the huge wealth gap between San Francisco and the rest of the country," Business Insider, May 25, 2018, https://www.businessinsider.com/weath-maps-cities-san-francisco-bay-area-2018-3

We recruited interviewees through purposeful convenience sampling within our personal networks, and conducted a total of eight user interviews, including one pilot interview for quality control. We aimed for a range of six to ten interviewees based on user experience industry standards[13]. We ultimately elected to cap the sample size at eight participants after determining that we had reached saturation in our data upon hearing repeated response patterns and limited new information[14].

We leveraged affinity mapping to cluster and identify common themes across individual data points drawn from interview notes, and found the following:

1. A majority of users perceived themselves as having moderate knowledge of environmental issues; however, and expressed interest in becoming more well-versed in this topic.

2. The vast majority of users shared that they did not have consistent sources of information pertaining to the environment, instead relying on one-off search engine queries and/or articles.

3. The vast majority of users identified climate change as the environmental issue that was most important to them.

4. The vast majority of users tend to be predictable in their grocery shopping habits, routinely visiting the same stores/merchants and/or frequently purchasing the same items.

5. With the exception of one user, none of our users use mobile applications while grocery shopping.

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[13] Kathy Baxter, Catherine Courage, and Kelly Caine, Understanding Your Users: A Practical Guide to User Research Methods (New York: Penguin Books, 2009), 234.
[14] Susan C. Weller, Ben Vickers, H. Russell Bernard, Alyssa M. Blackburn, Stephen Borgatti, Clarence C. Gravlee, and Jeffrey C. Johnson, "Open-ended interview questions and saturation." *PLOS One 13*, no. 6 (2018). https://doi.org/10.1371/journal.pone.0198606

6. A majority of users do consider environmental factors when making purchases; however, they identified time, convenience, and financial constraints as higher priorities.

7. When alluding to eco-conscious purchases and foods, users frequently cite wanting to improve their personal health along with wanting to make more eco-conscious choices.
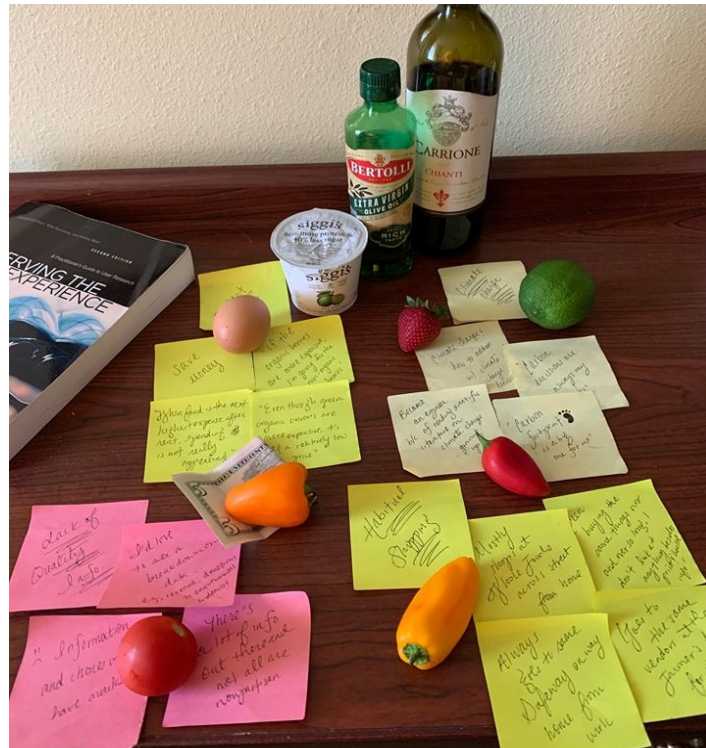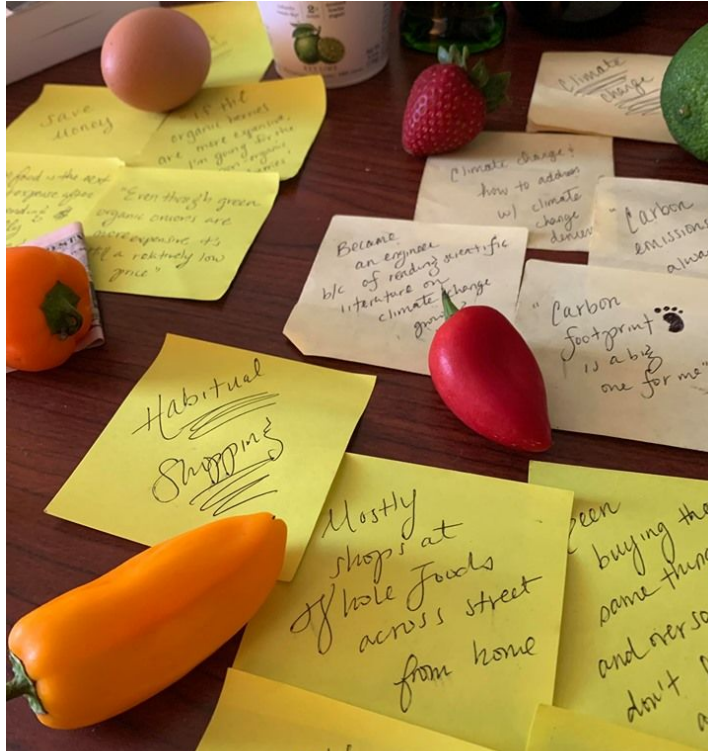
Affinity diagramming user interview data points.
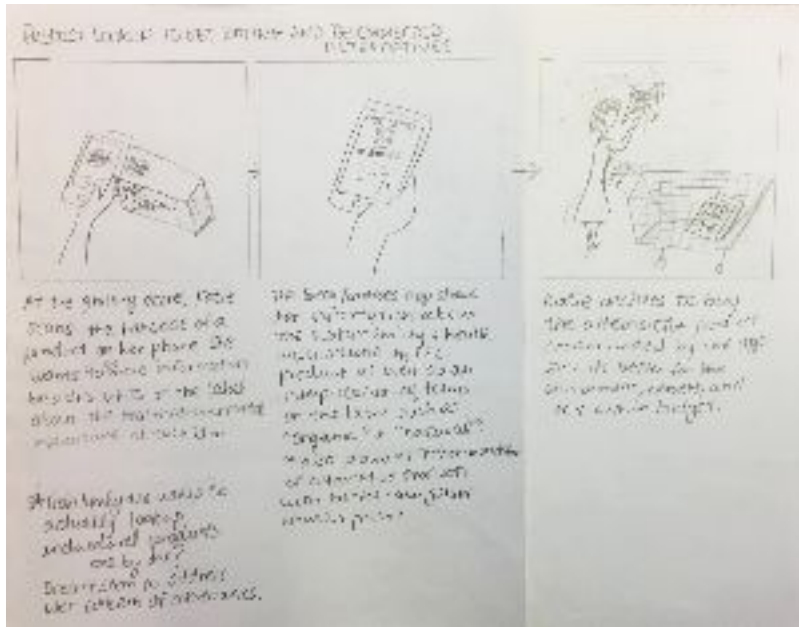
Concept Testing

Based on insights from our user interviews, we ideated and created three storyboards

representing unique ideas for our platform:

1. An educational website offering information on the sustainability and health implications

    of various kinds of foods: through the site, the user ideally gains a better understanding of

    how the foods they usually buy affects carbon emissions and their personal health.

2. A personalized assessment (quiz) of carbon footprint offering recommendations: by taking

    a brief quiz on their grocery shopping behaviors, the user receives a rating on the

    environmental implications of their current habits.

3. Product lookup to get rating and recommend alternatives: by scanning product barcodes

    at the grocery store, the user can find more information about the environmental and

    health impact of the item as well as an interpretation of label terminology (e.g., "organic"

    and "natural"). The system also provides recommendations of alternative products with

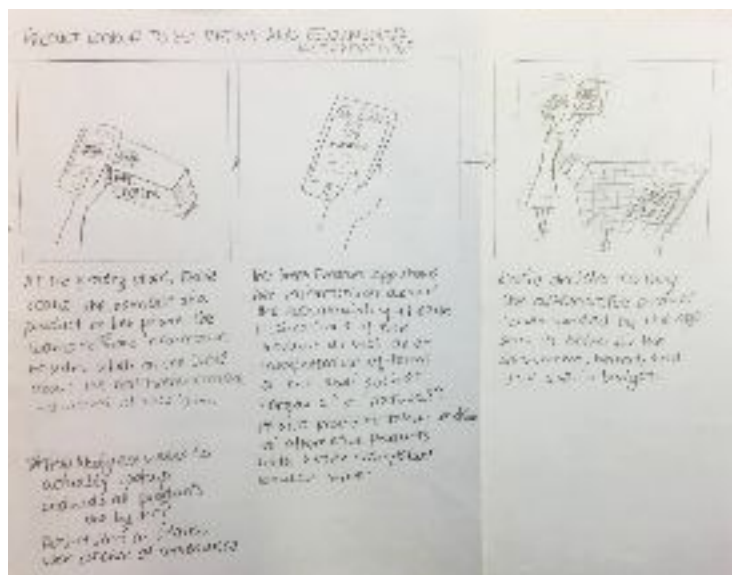   better ratings but similar price.

We then conducted remote concept testing with a purposeful convenience sample of five

participants by allowing them to review each storyboard (representing a "rough approximation" of

our platform) one by one and in randomized order. Through concept testing, we aimed to gauge

whether or not a user need existed for any of our ideas[15]. We sought to understand if users could

envision themselves using the concept(s)--and if so, under what contexts--as well as the rationale

underlying their responses (see Appendix B for concept testing guide).

We coded transcriptions of user responses, and found that with the exception of one user who

selected the item QR scanning concept as their favorite, the remainder of users expressed

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[15] Nick Babich, "A Comprehensive Guide to UX Research Methods," Adobe Blog, October 27, 2017, https://theblog.adobe.com/a-comprehensive-guide-to-ux-research-methods/

enthusiasm for the quiz concept. Notably, all users shared moderate enthusiasm for the

educational platform, and three noted they would ideally like a combination between the quiz

and educational concepts. As such, we decided to proceed by creating a platform that combined

features from both the quiz and educational platform concepts.

Concept 1: Educating users on the carbon footprint of food

Concept 2: personalized assessment (quiz) and recommendations

Concept 3: looking products while grocery shopping

Cognitive Interviews (Quiz)

After settling on creating an amalgam of Concepts 1 and 2, we then drafted a series of quiz

questions on a simple Google Doc. We then recruited five participants with whom we conducted

remote cognitive interviews, for which they simply read and responded to each quiz item on the

Google Doc aloud (see Appendix C for cognitive interview guide, which includes drafted quiz

items). The goal of these interviews was to test the clarity and validity of the quiz items we

constructed (i.e., to assess whether users understood what they meant and provided responses

that mapped onto the concepts we were interested in evaluating). We also wanted to optimize

question phrasing/wording and eliminate or otherwise clarify any incomprehensible terminology.[16]

Further, we sought to leverage participant responses to the mostly open-ended items from this

draft in developing--for upcoming versions of the quiz--close-ended response choices that are

reflective of their thought process. Separately, we sought to capture potentially missing [17] We

analyzed participant responses by coding interview notes/responses for emergent patterns[18], and

found that our quiz was missing products such as beverages and eggs, the "Bread/rice" category

name was too restrictive and did not account for other types of grains, and the "Sweets" category

name was similarly restrictive. Participants also noted the importance of including food

sensitivities along with allergies, found it difficult to prioritize three health goals

and--separately--three environmental goals, and did not understand the purpose of items asking

them to whether they preferred one specific food item (e.g., strawberries) over another (e.g.,

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[16] Romano Bergstrom, Jennifer Hunter Childs, Erica Olmsted-Hawala, and Nathan Jurgenson, "The Efficiency of Conducting Concurrent Cognitive Interviewing and Usability Testing on an Interviewer-Administered Survey." *Survey Practice 6*, no. 4 (2013). https://www.surveypractice.org/article/2887-the-efficiency-of-conducting-concurrent-cognitive-interviewing-and-usability-testing-on-an-interviewer-administered-survey

[17] Linda Naiditch, "How cognitive interviewing can improve your questionnaire design," Quirk's Media, July 2013, https://www.quirks.com/articles/how-cognitive-interviewing-can-improve-your-questionnaire-design

[18] Erika Yi, "Themes Don't Just Emerge — Coding the Qualitative Data," Medium, July 23, 2018, https://medium.com/@projectux/themes-dont-just-emerge-coding-the-qualitative-data-95aff874fdce

apples). We thus decided to incorporate missing items, revise terminology, combine

environmental and personal goals, and eliminate food preference items in our next iteration of

the quiz.

Sample Questions by Category

Budget *(Overall budget vs budget per item)*
- How much do you usually spend on groceries per visit /per week/per month?

Products they buy *(How specific should it be?)*
- How often do you buy **produce**? Which fruits/vegetables do you usually buy? (Select from list of choices)
- How often do you buy **meat**? Which of these do you usually buy? (Select from list of choices)
- How often do you buy **seafood**? Which of these do you usually buy? (Select from list of choices)
- How often do you buy **dairy**? Which of these do you usually buy? (Select from list of choices)
- How often do you buy **bread/rice**? Which of these do you usually buy? (Select from list of choices)
- How often do you buy **sweets**? Which of these do you usually buy? (Select from list of choices)
- How often do you buy …*(what else)*?

Dietary Restrictions
- Are you vegan/vegetarian/pescatarian?

Sample quiz questions from Google Doc

Usability Testing (Quiz)

After making revisions to our quiz items and developing response categories, we developed a

mid-fidelity prototype of the quiz that contained limited interactions on Figma, providing users

insight into the overarching structure and functionality of the quiz. We used a minimalistic black,

white, and gray color palette and did not include complex imagery in order to keep the focus of

usability testing on the quiz content and flow. We conducted remote usability testing at this stage

with five participants (see Appendix D for usability testing script), ultimately seeking to uncover

"whether [our] assumptions about how people will understand and use [our] designs as they

[were held] true."[19]

We used a rainbow spreadsheet/chart to document participant responses and identify recurring

behaviors and feedback across participants. In the rainbow chart, each participant was

represented by a unique color and formed separate columns on a spreadsheet tab; on the same

spreadsheet, each row represented a unique behavior or feedback. Filled cells indicated that a

participant exhibited a particular behavior or provided a certain piece of feedback (e.g., if a cell at

the intersection of "Participant A" and "Confusion on what GMO means" was filled purple, this

indicated that Participant A had difficulty interpreting the meaning of "GMO"). We opted for this

analytic tool, because rainbow charts can quickly and visually communicate which patterns are

particularly common or salient[20]. From our findings, we decided to implement several revisions to

our live version of the quiz, including: (1) switch order of frequency and product types questions

(e.g., select specific animal product alternatives first before answering frequency) to jog memory

and minimize confusion around what a category means; (2) show all dietary restriction items on

page (follow-up questions conditional on selecting "Yes" to the first can help jog people's

memories. People may not immediately think of dietary styles, sensitivities, etc.); (3) split

"Avoiding unnecessary waste" into 2 separate goals: Avoiding unnecessary food waste &

Minimizing food packaging (e.g., plastic and paper) waste; (4) offer more flexibility in frequency

(e.g., dropdown list of numbers; select per week or month); and (5) add a brief explanation of

"GMO" to reduce confusion and/or incorrect interpretations of the term. We also considered the

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[19] Elizabeth Goodman, Mike Kuniavsky, and Andrea Moed, Observing the User Experience: A Practitioner's Guide to User Research, (Waltham: Morgan Kaufmann, 2012), pp. 273
[20] Tomer Sharon, "The Rainbow Spreadsheet: A Collaborative Lean UX Research Tool," Smashing Magazine, April 11, 2013, https://www.smashingmagazine.com/2013/04/rainbow-spreadsheet-collaborative-ux-research-tool/

following user suggestions when starting to develop our quiz results: (1) incorporate friendly UX writing to minimize user guilt while emphasizing action; (2) incorporate actionable recommendations; (3) include data visualization to help interpret results.

1		Participant A	Participant B	Participant C	Participant D	Participant E
2	Colors					
3						
4	Understood "foodprint"					
5	Disliked length of Grocery section relative to other sections					
6	Noticed that certain (e.g., non-traditional and/or ethnic) produce missing (but generally okay with this)					
7	Grocery habits affected by COVID-19					
8	Sought more flexibility with frequency (e.g., once per month)					
9	Confused if eggs count toward meat purchase frequency					
10	Tends to stock up on certain items (e.g., doesn't frequently purchase grains or meat but will buy a lot at once)					
11	Assumed ice cream is part of dairy category					
12	Surprised by tofu being in grains, beans, & nuts					
13	Surprised by peanut butter being in snacks & desserts					
14	Not immediately sure what 'animal product alternatives' meant					
15	Has dietary restrictions but didn't immediately think of them based on first Yes/No question					
16	Had difficulty picking a 3rd important value					
17	Wants more clarification on why being asked for values / goals					
18	Confusion on what GMO means					
19	Interpreted "Avoiding unnecessary waste" as food waste					
20	Interpreted "Avoiding unnecessary waste" as packaging (e.g., paper & plastic) waste					

Sample of rainbow chart analysis of usability test behaviors / feedback across participants.

1. Produce

How often do you buy produce at the grocery store?

rarely or never	2-3 times per month	once per week	2-3 times per week	4+ times per week
○	○	○	○	○

Which of these produce do you usually buy?

bananas	apples	oranges	spinach	strawberries

3 / 7

Sample of mid-fi quiz prototype from Figma.

Usability Testing (Data Visualizations & Website)

The main purpose of the usability test was to check the effectiveness of the visualizations on the homepage of the website and to see how persuasive the narrative is. We hoped that conducting usability testing would help us to understand how users would interact with our website and to collect valuable feedback highlighting areas of improvement in terms of design choices and storytelling.

Methods

For this study, we used a combination of observation, usability testing, and semi-structured interviews. Before the participant interacted with our website, we asked them questions to gather demographic information and understand how much foreknowledge they have about the carbon emissions of food. The participants would then be asked to go onto the website, and we would observe how they interacted with various features and visualizations. They were also asked to speak aloud as they interacted with the website, and we would often probe with clarifying questions to understand their behavior and thought process. After they were done, we asked them to answer questions about the facts shown on the site to see how much knowledge they had gained and how much they would change their behavior.

Participants
- P1: 37 years old / Lawyer / Female
- P2: 27 years old / UX designer / Female
- P3: 33 years old / Banker / Male

We conducted usability testing with 3 users. One of the users was a student at UC Berkeley with a UX background, and two of them didn't have prior knowledge about the project at all. The convenience sample was appropriate, as they are millennials who can interact with apps and web pages. All participants said they think global warming is a real and imminent threat to the environment. None of them have previous experience with diet planning apps, and none of them have much knowledge about the carbon emissions of food except for the fact that meat products may be particularly bad for various reasons.

Analysis of Results

SECTION 1: COMBAT CLIMATE CHANGE WITH YOUR FOOD
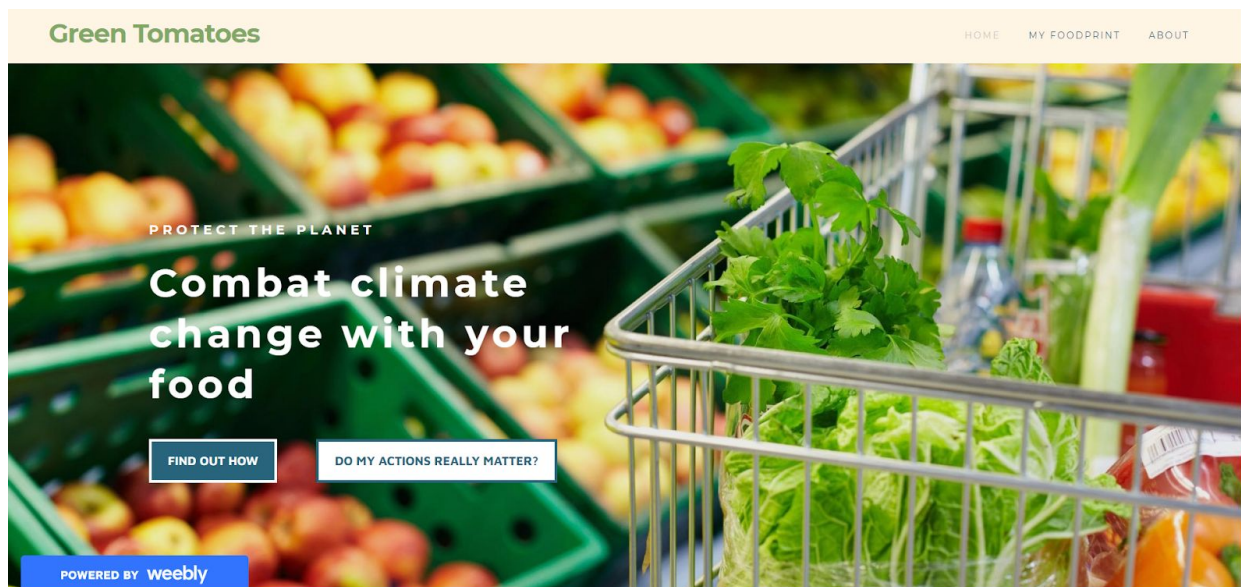
Intended Scenario

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

Task

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 CO_2 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: REDUCE YOUR CARBON FOOTPRINT FROM FOOD

Intended Scenario

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

Task

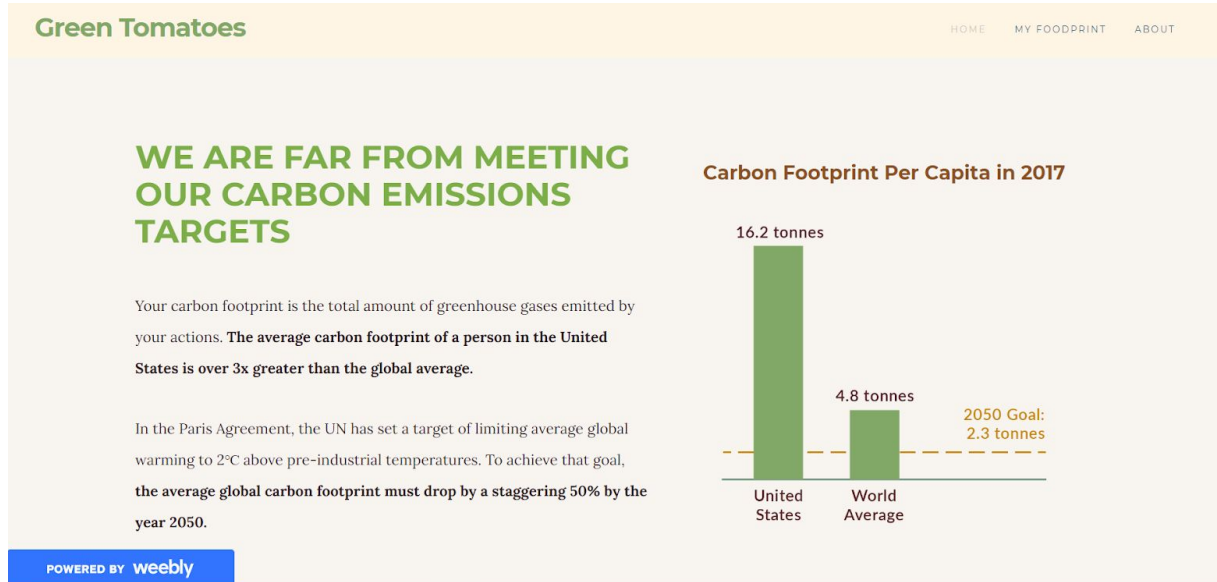Participants were asked to explain what they see and how they would interact with this section.

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 3: WE ARE FAR FROM MEETING OUR CARBON EMISSIONS TARGETS

Intended Scenario

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

Task

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

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 2C. 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 4: WHAT IF WE FAIL TO REDUCE OUR CARBON FOOTPRINT

Intended Scenario

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

Task

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 degree 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 5: WHY FOOD?
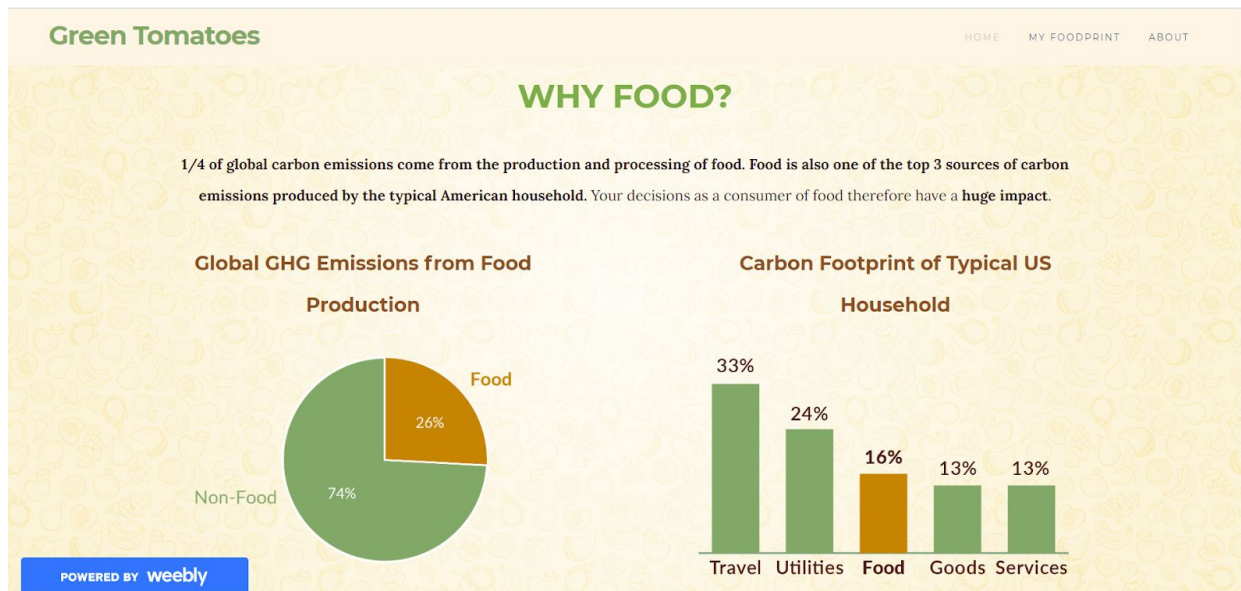
Intended Scenario

Users understand that food takes up an important portion in terms of CO2 emissions.

Task

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

section.

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
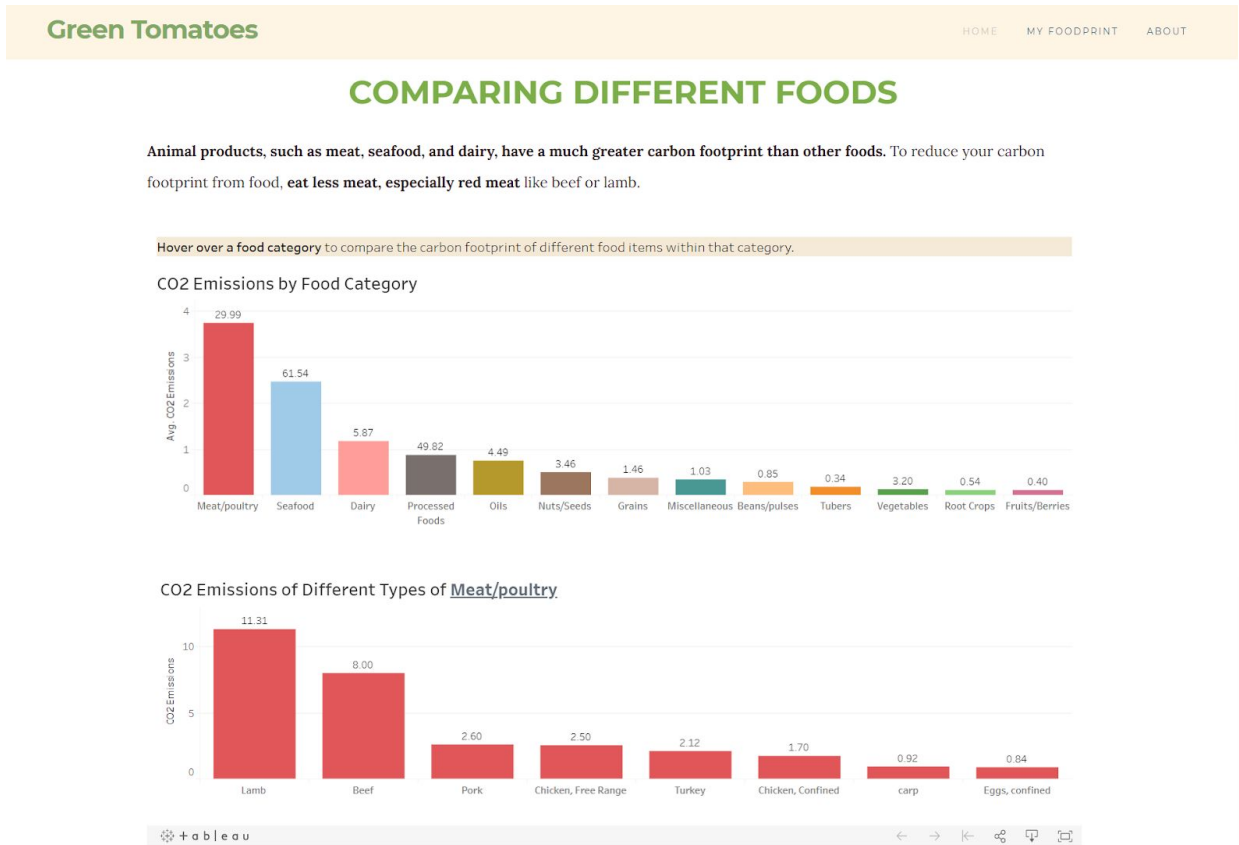
Intended Scenario

Users can interact with the visualization to learn about how CO_2 emissions are different

across the food category.

Tasks

Asked users to perform the following tasks:

T1: Find the average CO_2 emissions of dairy

T2: Find the average CO_2 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 CO_2 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 CO_2 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

  CO_2.

Interventions

- Fixed tooltip and labels on bars so that all the amounts are matching, and for the

  CO_2 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 CO_2 Emissions for Different Types of <Category> chart would be less

  likely to go unnoticed if the user doesn't scroll down.

SECTION 7: COMPARING DIFFERENT DIETS
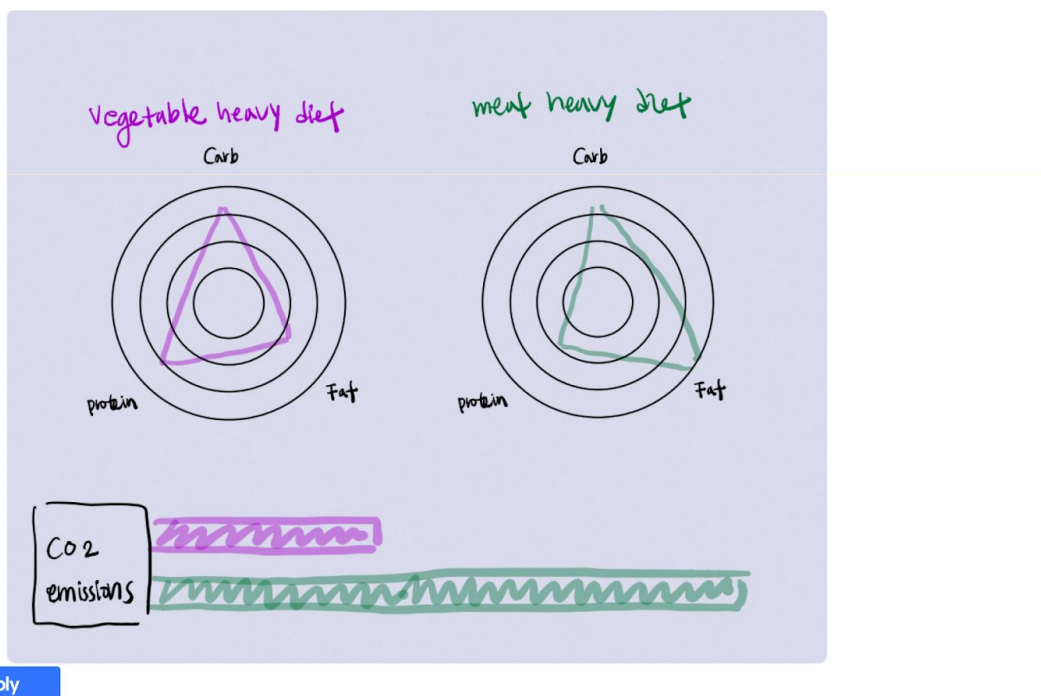
Intended Scenario

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

Task

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. He suggested changing the order of spider charts so that they can convey the message "switching from meat-heavy to vegetable-heavy".

Interventions

- Made spider charts interactive so that users can see exact figures when they hover on each graph.
- Added CO_2 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.

Post-Test Tasks

Users were asked to answer the following questions:

Q1: About how much of global carbon emissions come from food production?

Q2: Which category of food produces the greatest carbon emissions on average?

Q3: Rank the following foods in order of highest to the lowest carbon emissions.

(Chicken, Beef, Spinach, Rice, Milk)

Results

Tasks \ Participants	P1(83% accurate)	P2(100% accurate)	P3(67% accurate)
Q1	Correct	Correct	Wrong
Q2	Correct	Correct	Correct

Q3	Partially Correct	Correct	Correct

On average participants got 83% which shows a fair level of understanding.

Overall Feedback

P1 seemed to like the idea behind the website but suggested that it should show connections between carbon emissions and food up-front and why they're important for someone who doesn't know anything about this topic. Also, P1 mentioned that it should explain what the numbers on the graphs mean and why people should care. She felt that it seems more geared for people already interested in this topic as opposed to someone who hadn't ever thought about reducing their footprint. She suggested including more explanation to appeal to those people.

P2 questioned the flow of storytelling as it seemed like going back and forth from food to global warming and felt disconnected. She suggested that it may be better to start with a broader topic like global warming and narrow down to CO2 emission of food. She also suggested that it would be nice to end the flow with the quiz linked under "Find out how" since people learned about a lot of stuff and it could be beneficial to revisit in case they didn't take it at the beginning. In addition, she mentioned that It would be better to use "Foodprint" throughout the website to give a sense of connection or at least use a consistent term.

P3 preferred to see more visualization than text, and he said he didn't expect to read a lot of text when he first saw the website.

Final Design (Quiz)

The quiz is accessible from the "Take Quiz" button on the homepage of the Green Tomatoes

website, and consists of four main sections: Budget, Groceries, Dietary Restrictions, and Goals.

BUDGET

Based on our user interviews, it seems that cost is one major obstacle preventing consumers

from opting for more eco-friendly food options. The quiz therefore collects information about

users' grocery budget in order to provide recommendations that are within their budget. Based

on the results of the usability test conducted on the quiz prototype, we added the option for

users to provide their budget on either a weekly or monthly basis, instead of just a weekly basis.

GROCERIES

The groceries section is divided into six food categories: Produce, Meat & Eggs, Seafood, Dairy, Grains, Beans & Nuts, and Snacks, Dessert & Beverages. For each category, users are asked to select which foods within that category that they usually buy at the grocery store and to indicate approximately how often they buy those foods. This information would be used to estimate the carbon impact of users' groceries and incorporated into the final score they are given in the results.

DIETARY RESTRICTIONS

The quiz asks about dietary restrictions in order to avoid recommending foods that users are not able to eat. Specifically, we ask users to indicate whether they are vegetarian, pescatarian, or vegan and whether there are any foods they can't eat due to allergies or for personal reasons. If users answer Yes to the latter, an additional item appears prompting users to select which foods they are not able to eat. This item does not appear unless users answer yes in order to streamline the user flow and limit the amount of unnecessary steps users have to complete.

GOALS

In order to provide recommendations that would not only reduce the user's carbon footprint from food, but also help them to achieve other goals that are important to them, the quiz asks users to select up to three health or environmental goals. We figured that users would be more likely to follow our recommendations if doing so would help them to achieve their own personal goals as well as reduce carbon emissions, so our plan was to consider users' goals when developing their personalized recommendations.

RESULTS
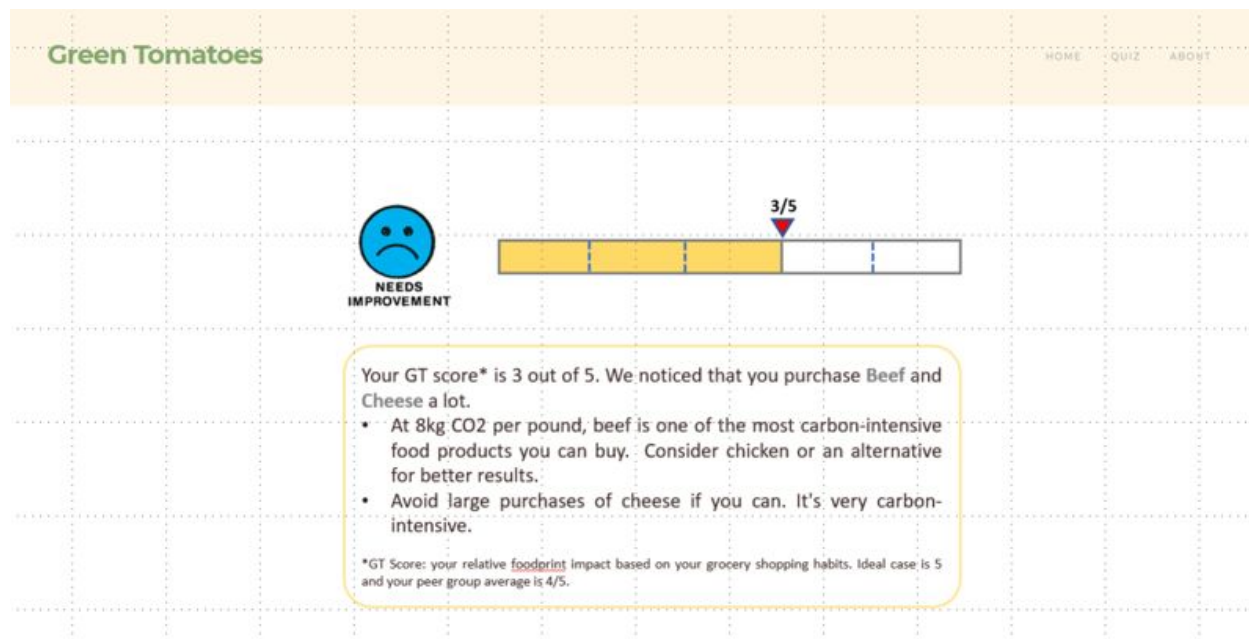
When users complete the quiz, the data they submit is automatically added to a database on the

cloud. We have written and implemented javascript code that retrieves and cleans the

submission data of the current user and stores it as a javascript object so that computations can

be done to determine the user's personalized results based on their quiz answers. Due to

unforeseen circumstances however, we were not able to implement customized quiz results in

the website, but we did create a mockup of what the quiz results could look like. Users would get

a score out of 5 indicating the carbon impact of their grocery shopping habits. The ideal score

would be 5 and the average for their peer group would be 4 out of 5. The mockup also calls out

specific carbon-intensive foods that users buy and provides less carbon-intensive alternatives.

**Final Design (Data Visualizations & Website)**

Based on the results of the usability study and feedback we received from users, we iterated on

our design to develop the final version of the data visualizations and website.

SECTION 1: COMBAT CLIMATE CHANGE WITH YOUR FOOD
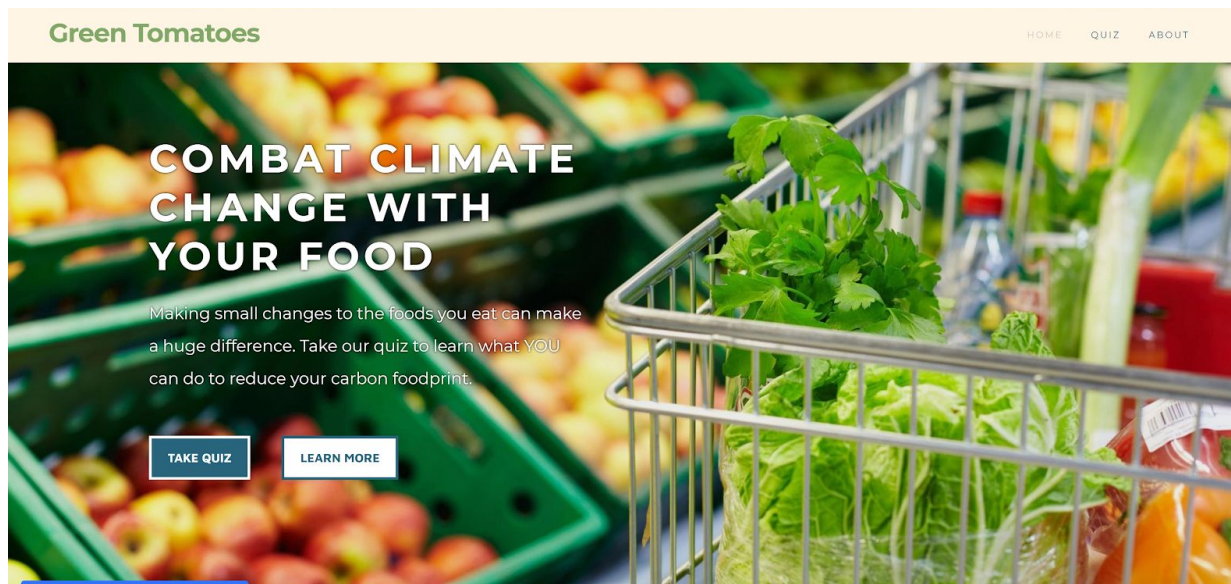
This section is the first thing that users see when visiting the Green Tomatoes website. Through the use of images and text, it conveys our key message that food plays a role in climate change and encourages people to make changes to the foods they eat in order to help combat climate change. This section also invites users to complete the quiz. 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.

SECTION 2: WE ARE FAR FROM WHERE WE NEED TO BE TO KEEP GLOBAL WARMING AT A SUSTAINABLE LEVEL
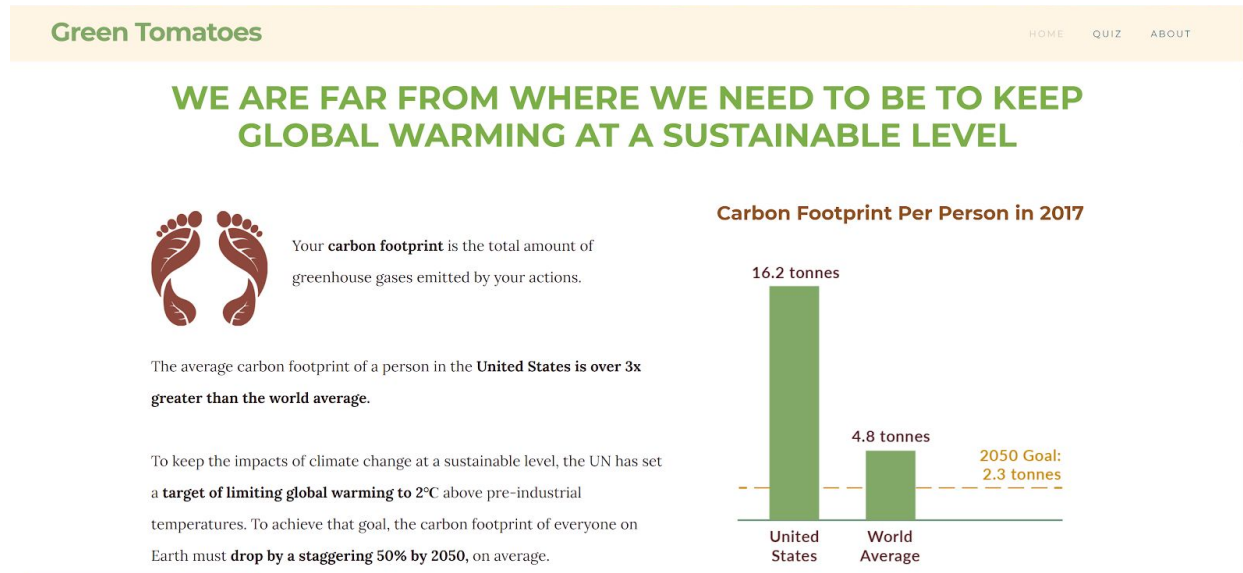
This section uses a combination of text, icons, and data visualization to convey to users that we are far where we need to be to keep global warming at a sustainable level. The bar graph emphasizes the huge difference between the average carbon footprint of a person in the United States and the global 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.

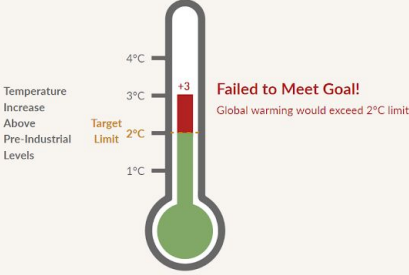**SECTION 3: WHAT IF WE DON'T REDUCE OUR CARBON FOOTPRINT?**

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.[21]

SECTION 4: REDUCE YOUR CARBON FOODPRINT

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

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[21] "Should You Be Thinking about Your Personal Carbon Budget?," Flight Nook, March 22, 2019,
https://www.flightnook.com/should-you-be-thinking-about-your-personal-carbon-budget

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.

SECTION 5: WHY FOOD?
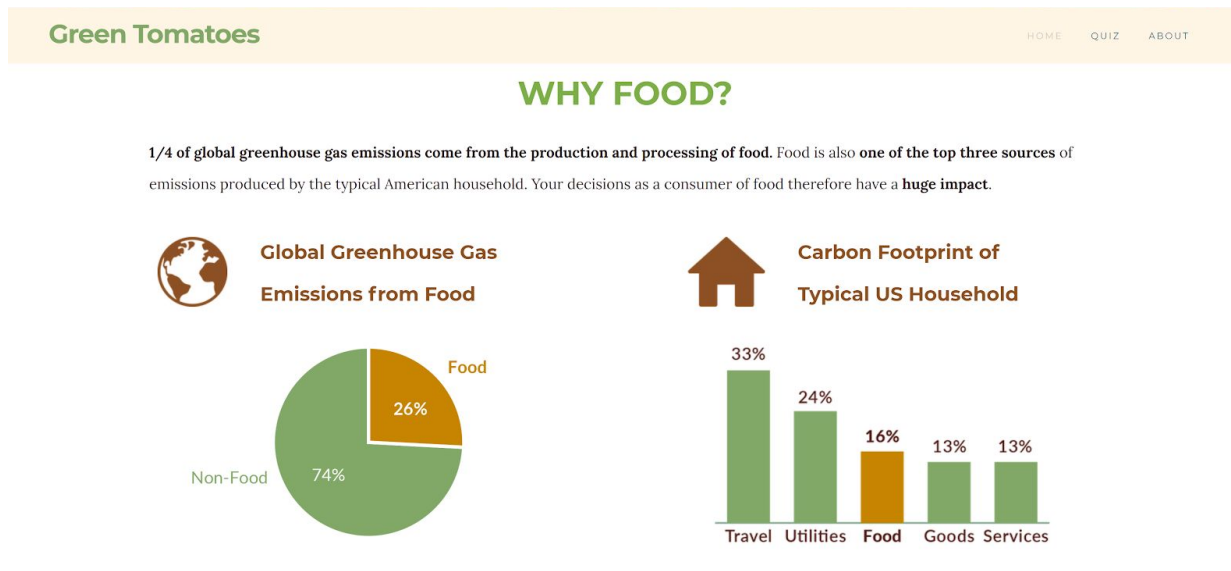
We imagine that users have likely heard a decent amount about conserving energy or driving less as ways to reduce their carbon footprint but have heard less about doing so by changing the foods they eat. Therefore, the motivation for this section was to explain why food is also an important element in 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.

SECTION 6: COMPARING DIFFERENT FOODS
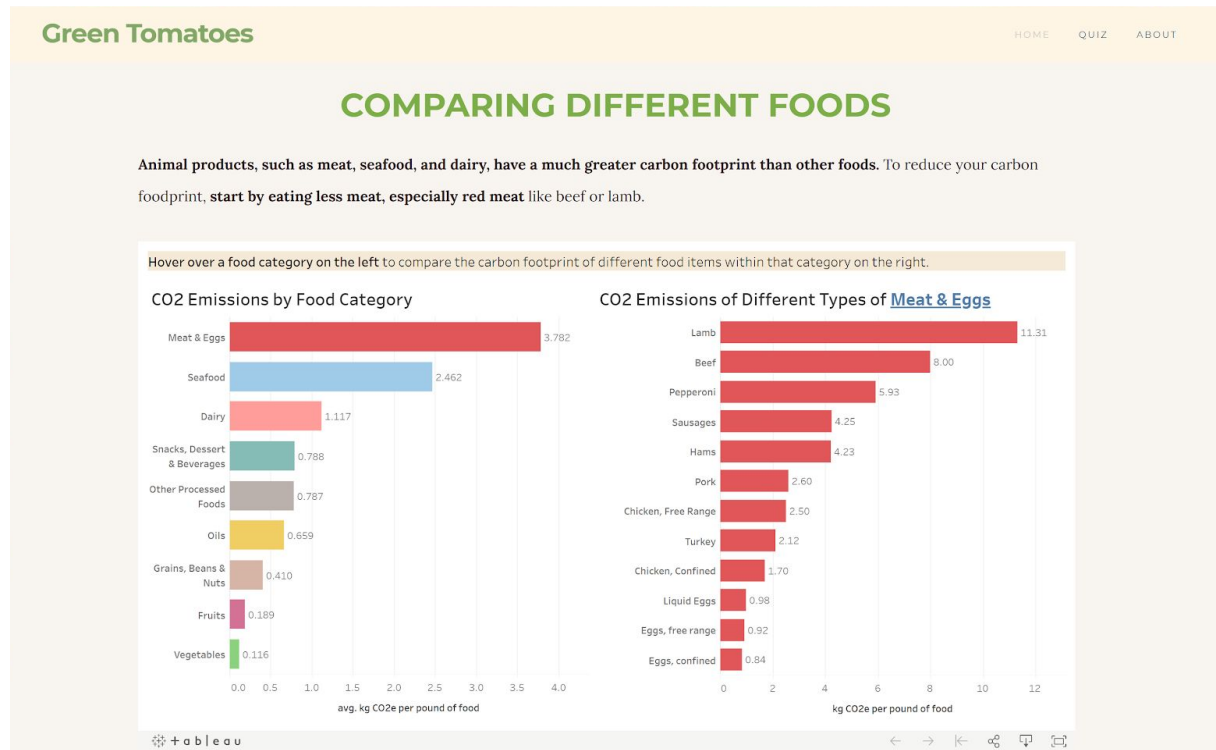
This section includes an interactive visualization that enables users to explore and compare the carbon emissions of different types of foods. In doing so, users can identify foods that produce high amounts of greenhouse gas emissions and find alternatives within the same category that produce less emissions. 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 CO_2 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.
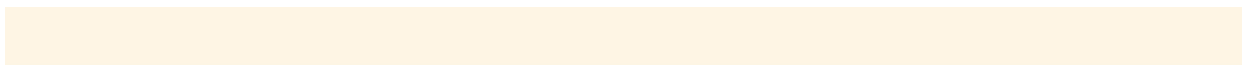
SECTION 7: NUTRITION AND CARBON FOODPRINT

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.

Data Process

Data Mining

At the beginning of the project we weren't 100% sure about what data we will need to develop our website, but we narrowed it down to three major parts - co2 emissions from food, nutrition facts, and cost information. Although we wanted to have co2 emissions data by brands, it turned out that wasn't entirely possible since disclosure of such information is not mandatory for the companies. Therefore, we pivoted to average co2 emissions by food items rather than by brands, and searched through existing databases used in previous research projects and articles.

The above screenshot summarizes our effort looking for an appropriate database. The main problem was many existing databases were outdated and collected in Europe not in the U.S. In the end, we found a great resource providing greenhouse gas emissions from food data which is derived and calculated using US Life-Cycle Inventory Database and IPCC Guidelines for National Greenhouse Gas Inventories. However, we could not obtain raw data from the organization, we had to manually compile the data to use.

Data Cleaning And Merging

After we found three main datasets we want to use, we noticed that they were using various units (kg, one serving size, ml, oz, lb, …) so that they have to be translated to a single unit somehow. We chose lb as a standard unit for convenience, and we were able to further translate into a serving size or kg as needed. In addition to that, some data points have missing values, so we did some more research to fill in with the most recent and reasonable values. The below screenshot is our database after the cleaning and merging process.

	A	B	C	D	E	F	G	H	I
1	food_category	food_commodity	co2_emissions	weight(pounds)	calories(kcal)	fat(g)	carbs(g)	protein(g)	cpi_2020_march
2	Beans/pulses	Beans	0.36	1	141	1	32	8.3	1.488
3	Beans/pulses	Lentils	0.24	1	1597	4.8	287	112	5.250
4	Beans/pulses	Soybeans	0.25	1	667	31	50	59	2.250
5	Dairy	Butter	0.53	1	3252	368	0.3	3.9	3.306
6	Dairy	Cheese	4.47	1	1202	97	18	64	3.907
7	Dairy	Sour Cream	0.1	1	617	48	32	16	1.980
8	Dairy	Milk	0.36	1	277	16	20	14	3.248
9	Dairy	Yogurt	0.41	1	277	15	21	16	1.626
10	Fruits/Berries	Apple	0.1	1	236	0.8	63	1.2	1.315
11	Fruits/Berries	Berries	0.1	1	259	1.5	66	3.4	1.930
12	Fruits/Berries	Bananas	0.1	1	404	1.5	104	4.9	0.576
13	Fruits/Berries	Olives	0.1	1	526	49	27	3.8	9.990
14	Fruits/Berries	Oranges	0.66	1	222	0.7	57	4.1	1.290
15	Fruits/Berries	Cherries	0.11	1	286	0.9	73	4.8	14.590
16	Fruits/Berries	Apricots	0.1	1	218	1.8	50	6.4	3.990
17	Fruits/Berries	Figs	0.7	1	336	1.4	87	3.4	8.990
18	Fruits/Berries	Strawberries	0.12	1	145	1.4	35	3	3.490
19	Fruits/Berries	Lemons	0.04	1	132	1.4	42	5	2.450
20	Fruits/Berries	Grapes	0.38	1	304	1.6	78	2.9	2.990
21	Fruits/Berries	Mango	0.03	1	272	1.7	68	3.7	1.000
22	Fruits/Berries	Peaches	0.1	1	177	1.1	43	4.1	2.990
23	Fruits/Berries	Pears	0.15	1	259	0.6	69	1.6	2.490
24	Fruits/Berries	Pineapple	0.04	1	227	0.5	60	2.5	6.990

Exploratory Data Analysis

EDA served two main purposes in our project. First, we wanted to make sure that our database is consistent with previous research. If not, we should have worried about the credibility of our resources. Second, we wanted to create a nice visualization to put on our website to persuade users. Many of them were introduced to you earlier in the visualization section, and others are attached below.

Calories from each nutrient
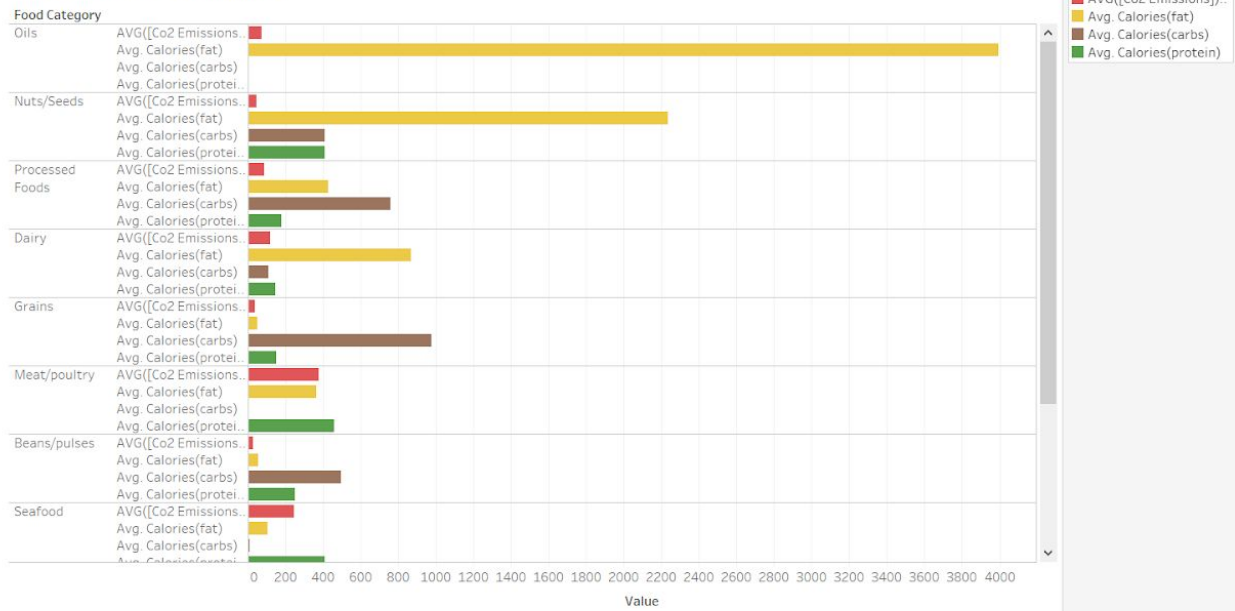
Co2 emissions vs consumer price
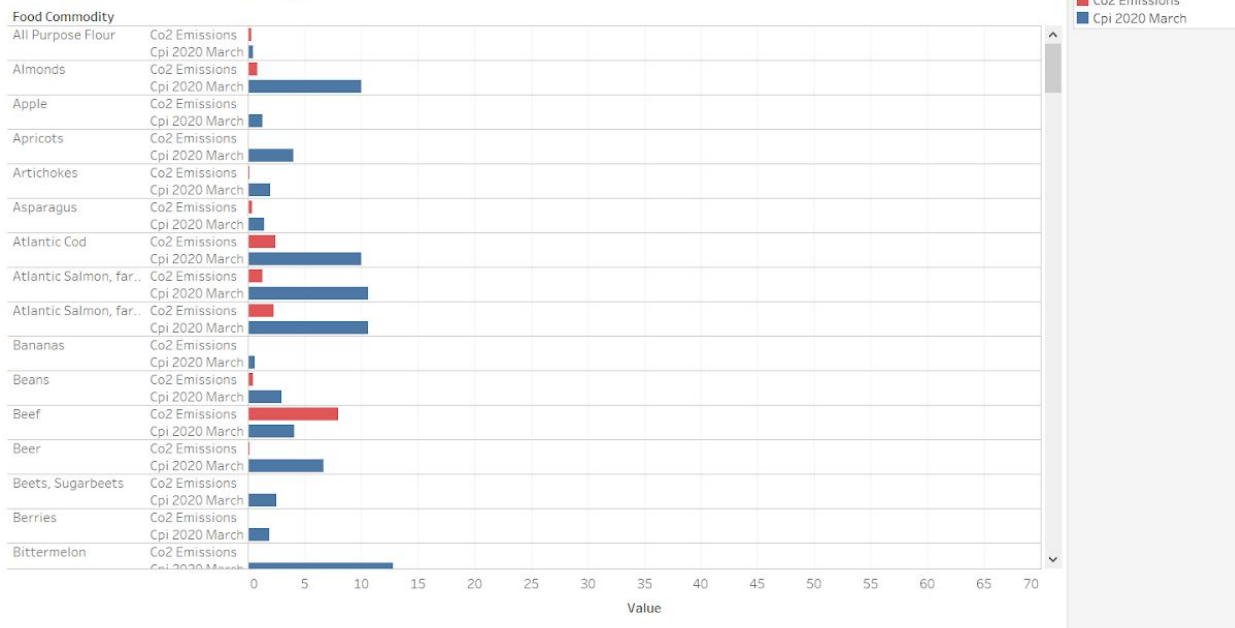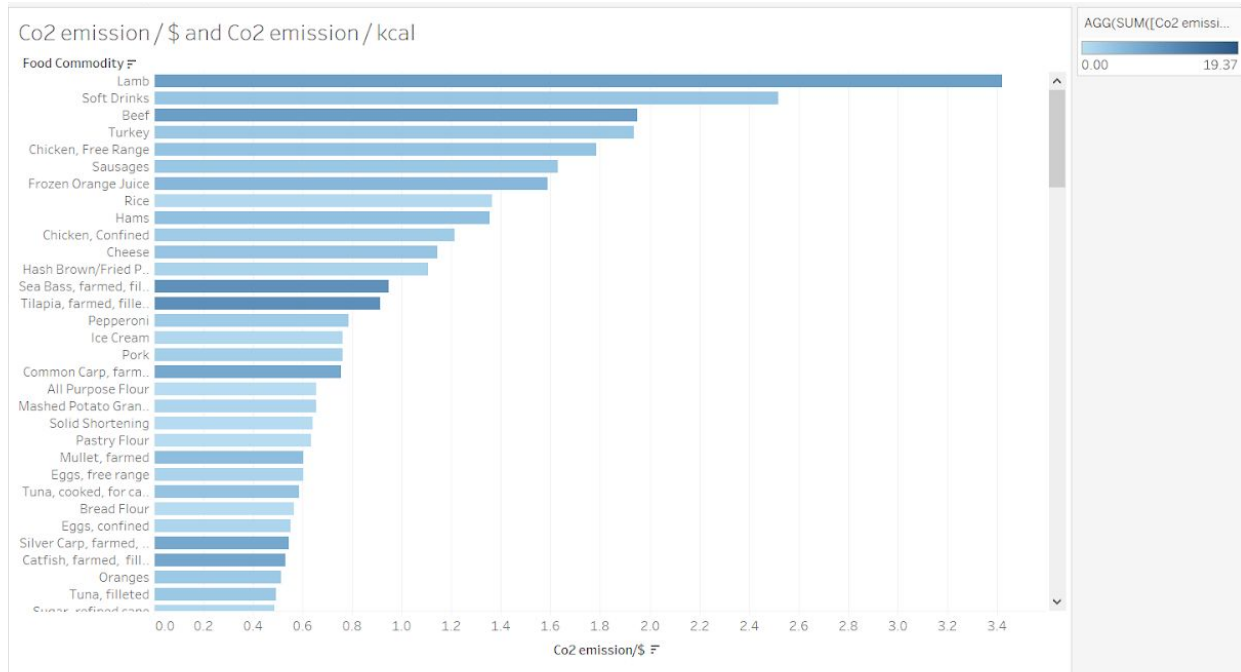
Summary of Databases

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	Section 5: Why Food? (Carbon Footprint of Typical US Household)	Website: The Nature Conservancy

with average criteria		
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 Diagnostic Quiz	Website: Foodemissions.com
Nutrition facts data by food items	Section 7: Nutrition And Carbon Foodprint Diagnostic Quiz	Website: https://www.nutritionvalue.org/
Consumer Price Index data	Diagnostic Quiz	Website: U.S. Bureau of Labor statistics

Discussion/Conclusion

Throughout our project, we encountered a number of challenges. For one, accessing the right data on carbon emissions of food was difficult. We gathered carbon emissions and nutritional data on a variety of food products from multiple, disparate databases that often lacked standardization. These sources also generally based their metrics on liquid volume or weight, which we found difficult to translate to our quiz since people typically find it hard to quantify how much of a particular food item they purchase.

With regard to future directions, we plan on further developing our quiz results and underlying metric, conducting additional usability testing on our website and quiz, and evaluating our impact by tracking behavioral changes across users. Specifically, we envision incorporating budget considerations into our survey results, which will require collecting additional data that may

involve the complexity of considering location-dependent variations in food prices. With access

to more time and resources, we would also recruit user research participants outside of our

personal networks and facilitate participatory design sessions to further channel the voice of our

users.

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Appendices

Appendix A: Interview Guide

Factsheet

	Interviewee #1	Interviewee #2	Interviewee #3	Interviewee #4	Interviewee #5	Interviewee #6	Interviewee #7	Interviewee #8
'Name'	A	B	C	D	E	F	G	H
Sex	Female	Male	Male	Female	Male	Male	Female	Male
Race / Ethnicity	East Asian	Hispanic, East Asian	Middle Eastern	Caucasian	White & Hispanic	Caucasian	African-American	South Asian
Age	Early 30's	Early 30's	Late 20's	Early 30's	Early 30's	Mid-20's	Mid-20's	Mid-20's
Hometown	Seoul, Korea	Orange County, CA	Gaithersburg, MD	Los Angeles, CA	Ukiah, CA	Lafayette, CA	Seattle, WA	Punjab state in India
Current City	Albany, CA	Oakland, CA	Gaithersburg, MD	Los Angeles, CA	Ukiah, CA	Milpitas, CA	Sunnyvale, CA	Berkeley, CA
Occupation	Graduate student - financial tech, accounting	Biologist	Education partnership consultant	UX Designer	Real Estate Photographer	Technical Editor; Part-time gigging musician	Project & program management at education nonprofit	Graduate student - artificial intelligence

Goal: explore user attitudes toward environmental sustainability and strategies/barriers to making sustainable choices as consumers. Understand depth of knowledge on the topic of environmental sustainability and leverage this as inspiration for the ideation phase.

Duration: ~45 minutes

Research Questions:

- To what extent do environmental considerations come into play in consumer decision-making?
    - Does this vary across different types of products / services?
    - Does this vary across other contextual factors?
    - What aspects of the environment and sustainability matter the most to consumers?
- How do consumers access information about how environmentally friendly products / services are?
    - How do these resources help them meet their goals?
    - In which ways might they be lacking?
- To what extent do consumers aspire to make more environmentally friendly purchases?

      ○   What explains this gap? / What are the barriers they face in their current experience?

Script

Question(s) / Prompt	Purpose
Thank you for taking the time to participate in this interview! Your insights will help us, a group of students at Berkeley, as we work on building a platform to address environmental issues. I will be asking you a few questions to learn about your thoughts on various environmental concerns. Please keep in mind that there are no wrong answers--all of your thoughts are valued. If at any time you feel uncomfortable with a question, you may choose to skip it or end the interview. [Optional] I will also be audio recording today's interview for myself to refer back to--This recording will be kept for internal use only, and will not be shared with anyone outside of my project team. May I have your consent to record? *[Start recording]*	Introduction Share context Set expectations Consent to record
What do you currently do? *[Probe for more detail if their work relates to sustainability]*	Warm-up & build rapport Learn about participant background & potentially domain expertise
Would you consider yourself an environmentalist? How knowledgeable would you say you are about environmental issues? What would you consider to be an environmentally conscious company? Why? To what extent are environmental concerns something you consider when purchasing products or services? In general, would you consider your current	Explore user beliefs and perceptions of environmental sustainability; gauge level of interest and knowledge Identify potential ideas for how to build model Explore user experiences with making sustainable choices as a consumer

habits as a consumer to be good for the environment? Why (not)?
 	
Tell me about a time when you made a decision to purchase or not purchase a product or service based on environmental concerns?
 	
● When was the last time you went grocery shopping?
   ○ Probes:
     ■ Where did you go?
     ■ What did you buy?
     ■ Did you read any product labels?
● When was the last time you purchased organic food?
● When was the last time you purchased non-GMO food?
● Tell me about the last time you purchased eggs.
   ○ Do you look for specific types of eggs, such as cage free or pasture-raised?
● Tell me about the last time you purchased meat.
   ○ Do you tend to purchase specific types of meat, such as beef or chicken?
● Tell me about the last time you purchased seafood.
   ○ Is there anything specific you look for like farm-raised or wild-caught?
● When was the last time you purchased an animal product substitute, such as plant-based meats or dairy products?
● How often do you try to purchase local ingredients?
   ○ When was the last time you shopped at a farmer's market?
 	
What would you consider to be some difficult aspects of making environmentally conscious decisions?
 	
How do you typically find information on how
	
	Identify pain points
	
	Gauge whether there is a market for Green Tomatoes
	
	Identify high-priority data points for model

environmentally friendly a company is? • Probe: what kind of information do you typically look for? • Probe: is there any additional information you wish you had access to? ○ How would this additional information fit into your current process of grocery shopping? Considering everything we've discussed today, is there one environmental issue that is most important to you?	
Is there anything else that you would like to share?	Offer opportunity to provide additional information Cool-off
[Optional - Ask as/if necessary] Before we wrap up, do we have your permission to collect some demographic information to help inform the design of the platform we're working on? You may skip any demographic questions you feel uncomfortable answering. - What is your current occupation? - Where are you currently living? - What is your hometown? - What is your age? - What is your gender? - What is your race and/or ethnicity?	Collect demographic information
This concludes the end of our interview. Thank you for your time! If you have any questions, comments, or concerns, I'm happy to answer them anytime.	Conclusion

Appendix B: Concept Testing Guide

Participant Summary (*n* = 5):
- 3 female and 2 male users
- 2 East Asian, 2 Caucasian, and 1 Pacific Islander user
- Age ranged from mid 20's to early 30's
- Job titles included Aircraft Technician, Product Manager, and Marketing Analyst
- Hometowns included Annapolis, MD, Lexington, KY, and Honolulu, HI

Duration: ~20 minutes

Testing Script:

Thank you for participating in today's concept test! You will be asked to review 3 storyboards illustrating 3 concepts for a digital platform on grocery shopping as part of my group's final project in our graduate program at UC Berkeley. I will show you these storyboards one-by-one. As you receive them, please describe your thoughts on each out loud. Afterward, I will ask you a few follow-up questions. Please bear in mind that there are no right or wrong answers, and that all of your feedback--including constructive criticism--is valued. If you feel uncomfortable at some point or would like to end the study, please let me know as well.

[Show Concept 1, 2, or 3 in randomized order]
Please read the story board out loud. As you do so, feel free to share any thoughts and points of confusion.
[Participant reads storyboard concept out loud]
What are your first impressions toward this concept?
Do you see yourself potentially using this platform? Why / why not?
Have you used any similar platforms in the past?
[Repeat above steps until all storyboards have been shared]

[Follow-up questions]
Which, if any, of the concepts did you like? Why?
Which, if any, of the concepts, did you dislike? Why?
Which, if any, of the concepts, was your favorite? Why?
Are there any changes that you would make to any of the concepts you saw today?
Is there anything else you would like to share?

Thank you for your time and feedback!

Appendix C: Cognitive Interview Guide

Participant Summary (*n* = 5):
- 3 male and 2 female users
- 2 White & Hispanic, 1 Pacific Islander, 1 Black/African-American, and 1 East Asian user
- Age ranged from mid 20's to early 30's
- Job titles included Web Developer & UX Designer/Researcher
- Hometowns included Salinas, CA and Fu'an, China

Duration: ~45 minutes

Interview Script:

Thank you for participating in today's cognitive interview! I am currently working with a group of students at UC Berkeley to develop a quiz on grocery shopping habits for our Master's final project. You will be asked to review a Google Doc containing a draft of quiz items. As you review the document, please read each quiz item and respond to it aloud. As you do so, please try to think out loud to share your thought process, points of confusion, and any questions you might have. Please keep in mind that there are no right or wrong answers, and any constructive feedback is appreciated.

[Share Google Doc quiz draft]

All right, now we are ready to begin. Again, starting from the top, please read each quiz item and respond to it aloud.

[Ask probing questions throughout interview]

[Quiz Draft]
Sample Questions by Category

Budget *(Overall budget vs budget per item)*
- How much do you usually spend on groceries per visit /per week/per month?

Products they buy (*How specific should it be?*)
- How often do you buy **produce**? Which fruits/vegetables do you usually buy? (Select from list of choices)
- How often do you buy **meat**? Which of these do you usually buy? (Select from list of choices)
- How often do you buy **seafood**? Which of these do you usually buy? (Select from list of choices)
- How often do you buy **dairy**? Which of these do you usually buy? (Select from list of choices)

- How often do you buy **bread/rice**? Which of these do you usually buy? (Select from list of choices)
- How often do you buy **sweets**? Which of these do you usually buy? (Select from list of choices)
- How often do you buy …(*what else)*?

Dietary Restrictions
- Are you vegan/vegetarian/pescatarian?
- Are there any foods you are allergic to?
- Are there any foods you don't eat for personal or religious reasons (or any other reasons)?

Health/Environmental Goals
- Which are most important to you? (Rank top 3 Health goals)
    - Reducing calorie intake/losing weight
    - Getting a more balanced diet
    - Avoiding added chemicals/hormones in food (ie eating organic)
    - Eating nonGMO
    - *(What else?)*
- Which are most important to you? (Rank top 3 environmental goals)
    - Animal cruelty in food production
    - Avoiding unnecessary waste
    - Contamination from pesticides/chemicals
    - Protecting natural habitat/wildlife
    - *(What else?)*

Personal Tastes/preferences
- Are there any foods you dislike?
- Do you prefer A or B? (eg. grapes or strawberries?) (List different pairs of foods and ask for preference)

Location
- Zip code or city+state?

[Follow-up questions]

What were your overall thoughts on what you saw today?
Were there any parts of the quiz you particularly liked? Why?
Were there any parts of the quiz you particularly disliked? Why?
Were there any questions you found difficult to answer? Why?
Were there any parts of the quiz you would change? Why?
Do you have any other additional feedback?

Thank you for your time and feedback!

Appendix D: Usability Testing Guide (Quiz)

Participant Summary (*n* = 5):
- 3 male and 2 female users
- 2 East Asian, 1 Black/African-American, 1 Pacific Islander, and 1 White & Hispanic user
- Age ranged from mid 20's to early 30's
- Job titles included Payroll Administrator & Graduate Student
- Hometowns included Snellville, GA and Wuhan, China

Duration: ˜45 minutes

Testing Script:

Thank you for taking the time to participate in today's usability study! You will be asked to take a quiz on your grocery shopping habits, which will be one component of my team's master's final project at UC Berkeley. We are hoping to improve our designs, so please try to think out loud as you take the quiz and feel free to be honest with your feedback. There are no right or wrong answers, and you won't hurt my feelings if you offer constructive criticism. If you find any part of the quiz difficult or confusing, please do not feel bad either. And if at any point you would like to skip a question or end the test all together, please let me know.

Do you have any questions for me at this point?

Great! --Next, I will share a link with you in the Zoom chatbox. Please click on it. Once you have it open, please share your screen with me via Zoom.
https://www.figma.com/proto/p8vw7LQgeRS2D1PqzjNTAI/Green-Tomatoes?node-id=64%3A26&scaling=min-zoom

Awesome. Now that you're sharing your screen, I would also like to create a recording of our test for my own review: your face does not have to be part of this recording and at no point will it be shared with people outside of the team [give option to turn participant camera off]. Do I have your consent to start recording? [Start recording on Zoom]

Great--Thank you!

Imagine that you are scrolling on your Facebook feed and encounter an ad featuring this quiz. Curious about what your carbon "foodprint" is, you proceed to click on the ad, which takes you to this page.
As you review the quiz, feel free to describe what you see on the screen and share your thoughts, feelings, and other feedback out loud as you move through the quiz. Also, please bear

in mind that since this is just a simple prototype, there will be relatively limited visuals and interactions, so you will run into a lot of dead ends while clicking around. However, indicating what you might expect to happen if you click on something and what options you would select if you were able to click on them would still be really helpful information to know.

Now, please begin taking the quiz.

[Share Figma prototype link. Participant takes quiz]

[Potential ad-hoc probes throughout if they are more hesitant to share feedback]:
Can you describe what you see here? What response options would you select, if any? How do you feel about the response options? What are your thoughts on this question? Why? … Etc.]

This concludes the test--Before we wrap up:
Do you have any additional thoughts on the quiz?
Do you have any questions for me?

Thank you again for your time! If you have any further feedback, questions, or concerns, please feel free to reach out to me.

Appendix E: Usability Test Script (Data Visualizations & Website)

Thank you for taking the time to participate in today's usability study! You will be asked to review and perform tasks on the Green Tomatoes website. Please try to think out loud as you see various features on the website and feel free to be honest with your feedback. Keep in mind that there are no wrong answers--all of your thoughts are valued. If at any time you feel uncomfortable with a task or question, you may choose to skip it or end the test.

Do you have any questions for me at this point?

Great! -- I would like to create a recording of our test for my own review: your face does not have to be part of this recording and at no point will it be shared with people outside the team [give the option to turn participant camera off]. Do I have your consent to start recording? [Start recording on Zoom]

First, I would like to ask you a couple of initial questions.

Pretest questions:
- Can you tell me how old you are?
- What is your occupation/profession?
- How do you identify your gender?
- Have you ever used apps to help plan your diet, such as NoomCoach? If so, how was your experience?

○ What are your thoughts on global warming?
○ Could you tell me what you know, if anything, about the carbon emissions associated with food?

Next, I will share a link with you in the Zoom chatbox. Please click on it. Once you have it open, please share your screen with me via Zoom.

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

Awesome. Now that you're sharing your screen, let's move on to the tasks

Please look through the homepage of the website from the top to bottom, going through each section in order one by one. Again, feel free to describe what you see on the screen and share your thoughts, feelings, and other feedback out loud as you move through the page. Also, please bear in mind that since this is just a simple prototype, there will be relatively limited visuals and interactions, so you will run into a lot of dead ends while clicking around. However, indicating what you might expect to happen if you click on something and what options you would select if you were able to click on them would still be really helpful information to know.

[When user gets to the sketches for temperature change viz]
For this section, please tell us what you see. How would you interact with this visualization? What would be the expected response and behavior?

[When user gets to the Tableau viz comparing emissions of different foods]
Can you find the average CO2 emissions of dairy? What about seafood? For meat, try to find which types of meat have the lowest and greatest emissions. Do the same for grains.

[When user gets to sketches for CO2 emissions from different diets]
For this section, please tell us what you see. How would you interact with this visualization? What do you think after seeing this? How do you think we can make it better?

[After user finishes going through all sections of homepage]
Thank you, please close the website and stop sharing your screen.

Before we end the test, I would like to ask some final questions.

Post-test questions:
1. What are your overall thoughts on this website?
2. About how much of global carbon emissions come from food production?
3. Which category of food produces the greatest carbon emissions on average?
4. Rank the following foods in order of highest to lowest carbon emissions.
    a. Rice
    b. Beef
    c. Milk
    d. Spinach
    e. Chicken

5. How likely are you to make changes to your grocery shopping habits after interacting with this website?
   a. Very Likely
   b. Likely
   c. Neutral
   d. Unlikely
   e. Very Unlikely
6. [If they answer very likely or likely] What specific changes do you think you might make?
7. [If they answer neutral, very unlikely, or unlikely] Would you mind explaining why?

This concludes the usability test. Do you have questions or comments for me before we end?

Thank you for your time!