Executive Summary

Sproot is a new Boston-based company aiming to make healthy food fun and attractive to kids, and easy for parents. The primary goal of Sproot’s mission is to increase intake of healthy, nutritious food by kids; furthermore, the company hopes to make healthy food more readily available for adults as well, and to make such food a convenient, tasty, and attractive choice; and finally, to minimize the harmful impacts that production and preparation of food has on the overall environment. To support achieving these objectives, our team was asked to create a tool using Excel that will merge into Sproot’s current spreadsheets of menu items and the nutritional value of the various ingredients, but which will add to the information already captured in these spreadsheets further data pertaining to the environmental impact of each ingredient. To create this tool our team conducted thorough research on all the existing literature covering the impacts of different food products, both papers presenting original research and higher-level works aggregating findings from numerous studies; conducted interviews with experts; and sorted all of Sproot’s ingredients into groupings that matched up with the relevant information we uncovered in our research. All of our findings we assimilated into the spreadsheets currently used by Sproot, adding an environmental dimension to guide selection of menu items for overall best balance of nutrition, price, and impacts. The major finding of our work is that how or where food is produced (e.g. organic vs. conventional; domestic vs. international) are weaker effects than food type: animal and especially cow products have far greater impacts than do fruits, grains, or vegetables. Thus, we conclude that choices of type of food are more impactful than choices about different ways of producing the same foods, or the distance food travels from farm to plate.

Background

Food choices are among the most fundamental decisions we make in shaping our lives: as the saying goes, “you are what you eat.” What we choose to eat also affects our impact on the planet, as different foods are associated with different activities that require different amounts and types of energy, of land, of chemicals, and of other inputs. Food choices matter both for the body itself, and for the health of the world in which we live. Yet strikingly, over the past century the massive increase in complexity of human-built systems and in specialization of labor within the many links of the food value chain have moved consumers further from the sources of their food and from a clear relationship and understanding of the impacts of their food choices than at any previous point in history. The US population is suffering from having lost the connection to food, as shown by the obesity epidemic, rising rates of diabetes, and of heart failure, stroke, and
other food related illnesses. Furthermore, the US demand for beef, corn, and other impact-intensive foods is damaging the global biosphere disproportionately relative to population size. Enter Sproot, an as-yet small Boston startup with the mission of renewing and improving our relationship to food. Sproot wants consumers to be able to choose fresh, nutritious, tasty food as easily as we now pick up highly processed, preserved, and prepackaged food items that contain numerous unwholesome chemicals and which are environmentally harmful in production and in the trash these items generate through throw-away packaging. Sproot’s meals are selected and carefully designed to feed the body what it needs without any chemicals that may contribute to poor health. They are packaged only in durable containers that return to the company for long-term repeated use. And to the extent possible in today’s world, the foods that go in the reusable containers have minimal impact on the overall environment. However, the real work behind this mission is far more difficult than one might imagine before taking a closer look.

Project Context

Sproot is a company with a lofty and important mission: improving the meals we eat, in terms of flavor, healthfulness, and nutritional quality, and also in terms of the impact to the planet caused by producing and delivering these meals. Sproot, founded in late 2012, currently serves only the Boston area and focuses specifically on lunches for kids in preschool and daycare. As stated on the Sproot website, the immediate goal is to “make eating [healthy food] fun for kids and school lunch easy for parents.” Easy is important, as one of the major accomplishments of the food system in the US is unprecedented convenience and speed, requiring very little effort from consumers. As well as food targeted for kids, Sproot offers lunches and catering for adults, and may eventually enter larger markets and have widespread impact on the range of food choices available to people of all ages, and in geographic regions beyond Boston. In Sproot’s own words:

“Sproot exists because a handful of people are crazy about feeding people exceptionally well. We also want to change the world while preserving the bits we consider precious, which is why we’ve taken on the Herculean task of designing and producing our own food and delivering it in reusable containers. This means we’re working to source as many local and organic ingredients as possible. We can’t do everything 100% at once, but that’s our long term goal.

“In the short term, our number one priority is to make an impact one healthier happier customer at a time.”

To one unfamiliar with the intricacies of US food production and supply systems, the task Sproot was created to carry out may appear easy to accomplish. Indeed, it almost seems simpler than the status quo: to start with relatively few, fresh, whole food inputs such as vegetables, fruits, and

whole grains rather than the long lists of processed ingredients that are normally found on the packages of foods available off the shelf in most stores; to base menus on nutritional science; and to assemble attractive meals in reusable containers really does not sound especially difficult. For customers, there is no debate around the fact that food of this type provides the optimal nutritional foundation to support lifelong health and both physical and cognitive development—and parents typically love their kids and want to give them the best chances possible in life. One would expect the target customers of Sproot to be highly responsive to food quality. However, even on a single dimension such as being conscientious about the impact of food choices, serious challenges to that goal are endemic to the system in which we live, requiring extensive efforts on the part of Sproot to overcome and thereby stay true to the company’s vision. These efforts carry a cost, and parents choose foods based in part on price, and also accounting for kids’ preferences.

A key pillar of the Sproot mission is to reduce the environmental impact of the meals it delivers, so as to not contaminate and threaten the overall environment that supports all life on Earth. To fully grasp the scale and nature of the obstacles Sproot faces in meeting this goal, it is first necessary to understand the larger context of the food industry, as it exists today. In the United States, almost a tenth of all energy consumption is required for the production, processing, and transport of food.\(^2\) Still more energy is consumed in the storage, preparation, and disposal of food and food waste; almost a third of all energy used in providing the US population with food is actually taken up by household storage and preparation. In excess of a factor of seven greater fossil fuel energy is currently required to produce food energy: recent studies have shown that the US consumed about 10.3 Quads of fossil energy to provide only 1.4 Quads of food energy per year (1 Quad = \(1\times10^{15}\) BTU).\(^3\) Although farming and producing food in-country consumes a lot of energy, that is only part of the picture, as the average American meal today contains food products from five countries outside the US, and the average “food miles,” or distance traveled from source to plate for food in the US are between 1,300 and 1,500 miles per meal.\(^4\)

- Although it is well understood that food production, transport, storage, and preparation consume a very significant percentage of all energy used in the US, to calculate the exact impact of the US food system with any precision is extremely complex and challenging.

- If one defines “impact” in the case of the food system as any and all deleterious effects relating to food consumption on humans and the natural environment, then in addition to energy use we must consider, for example:
  - Changes in land use such as deforestation
  - Contamination of water due to pesticides, herbicides, fungicides, and fertilizers

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\(^3\) http://www.slideshare.net/robabrams/environmental-impact-of-the-us-food-system

The building of roadways for the purpose of moving food
- Discharge of oil, grease, and chemicals from ships moving food by sea
- Health effects on workers spraying pesticides, and on people eating food with such chemicals still present and thus ingested
- The list goes on practically forever!

- Estimating the energy used by all the refrigerators in the US is hard enough; considering the energy that went into making and moving the refrigerators is yet harder:

  - Lights in the stores where the equipment was sold
  - Energy for factories where the refrigerators were made
  - The making of that factory, and of the components that went into it
  - Mining or otherwise extracting or harvesting of all materials
  - Making the machinery that did the mining, extracting, or harvesting
  - Runoff and atmospheric pollution from the mines
  - Clearing of land for the mines, the factories, and all the rest
  - Such complexity is completely beyond the range of practical measurement

To handle the near-infinite complexity of analyzing the environmental (and hence the social, as all environmental events also at least potentially have a connection to human life) impact of the American food system, boundaries must be drawn around the core activities that can and reasonably should be taken into account. As the single greatest environmental concern and threat to human existence in the world today is evidently global climate change, the units of analysis selected for the purpose of ranking the ingredients used by Sproot are carbon and methane emissions, the two most prominent heat-trapping gases (“greenhouse” gases, or GHG’s). Furthermore, the activities that release such gases in conjunction with the food system are, for the current purposes, limited to directly farming and moving plants and animals used for food.

**Project Objectives**

Sproot sought a tool that will allow the company to automatically label the list of ingredients used in Sproot’s meals according to environmental footprint. Such a tool will allow Sproot to match ingredients’ footprint with their desired nutritional and flavor value per meal, and hence decide which ingredients to select in lieu of others when designing menus.

A menu will be planned according to certain nutritional values managed with a high degree of detail (different amounts and types, as applicable, of calories, sugars, carbohydrates, proteins, lipids, minerals, vitamins and cholesterol), as recommended for the demographics of Sproot’s
target consumers by the Dietary Guidelines for Americans (2010)\(^5\). These values are balanced according to the recommendations but Sproot also needs to take into account the environmental impact that the ingredients have, as well as taste preferences of children and goals of parents. Parents have an important influence and indeed the final word on which meals are purchased. Nevertheless, children’s preferences are key in the decision, as parents wish their children to eat their meals completely during their lunch breaks. As taste preference plays an important role in the menu design, so does price, and therefore the selection of ingredients becomes a complex optimization problem with several dimensions and decision variables (nutritional value, environmental impact, taste preference and costs). As an example to illustrate Sproot’s challenging menu decision process, despite the high environmental impact associated with cheese, Sproot still includes dairy products in menus due to children’s taste preferences. Depending on source, the footprint of cheese may be comparable to that of pork, chicken, or even beef, ranging from as low as 8.0 (kg CO\(_2\) equivalent GWP*100/kg) for that produced in Sweden, to 9.0 for that produced in the Mid-Western US, to as high as 12 for that produced in Denmark [Lee, et al., 2013].

With a clear visualization of the ingredients’ relative footprint or environmental impact, Sproot’s menu decision process will not be completely solved, but it should, at least, be better informed. Currently, certain decisions are made concerning whether or not to include ingredients that are known to have a higher footprint. Some values for certain meal components and food have already been obtained by Sproot, and are kept in a simple database for reference, but, as it will be seen in Section 3 (Methodology, Analysis and Results) these values may vary significantly\(^6\) depending on countless factors such as land and fertilizer use, weather, transportation method, amount of time that a certain ingredient or food is kept refrigerated, the efficiency of the equipment, the production processes used to manufacture the refrigerator and other fixed assets, and whether the food has been organically grown or not, among many other factors. A relative environmental impact scale will acknowledge the impossible mission\(^7\) of measuring an exact number of carbon equivalent grams per gram of food, but will still enable reasonable awareness on the impact of food choices and the ability to either replace substitute ingredients within meals or plan meals differently to achieve a lower environmental impact.

Sproot has two additional business goals behind determining the relative environmental impact of their menus. The first is to market their sustainability strategy as a differentiator among their target customers and potential sources of funding. By addressing the difficult task of measuring their menus’ GHG footprint and being transparent to the public about their menu choices’ impact over the environment, Sproot will signal true concern for the environment and for doing business

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\(^5\) This guideline is published jointly by the U.S. Department of Agriculture (USDA) and the U.S. Department of Health and Human Services. It may be consulted at: http://www.cnpp.usda.gov/Publications/DietaryGuidelines/2010/PolicyDoc/PolicyDoc.pdf

\(^6\) Christina Ingersoll, Strategic Systems Integration Coordinator at COSA, and one of the consulted experts, has stated that footprint values could vary even 1000% depending on the variables within the value chain of each food or ingredient.

\(^7\) Both consulted experts, Christina Ingersoll and Edgar Blanco, have explicitly acknowledged the unfeasibility of measuring CO\(_2\) equivalent footprints in food.
in a sustainable way. The second is to target customers (mostly parents and adults to which the meals are offered) as audiences of their educational campaign. Parents are primarily concerned with two issues: that their kids get fed well and eat their entire meals during the time given at schools, and that the food budget is affordable. When analyzing parents’ food preferences, Sproot has realized that their concern over the environmental impact of their food choices comes in toward the very bottom of the list. Therefore, reaching parents with thoughtful information on the relative environmental impact of the meals offered is intended to help educate parents on the importance of valuing food that is produced and sourced sustainably. At the same time, word of mouth will hopefully spread awareness about Sproot’s business model and its benefits rapidly through the community and other potential customers. Finally, for educational purposes the information will be made accessible to the kids who eat the meals, and to the schools they attend.

To summarize, Sproot has three objectives in measuring the environmental impact of its menus:

1. To make sure Sproot complies with a crucial pillar of their business strategy, i.e., to provide healthy, sustainable food with the minimal negative effect on the environment

2. To offer a credible sign of belief and conviction about their sustainability strategy to stakeholders and to potential sources of funding

3. To educate the community, especially their target customers through a thoughtful and friendly manner on how their food choices impact the environment

Methodology, Analysis & Results

The challenge of supplying adequate nutrition for humanity through supply chains that don’t harm the carrying capacity of the planet is a key element in the global sustainability challenge. Sproot’s concern about how to quantify the impact of dietary choices lead our team to mapping research and the existing literature on environment impact of food and agriculture, comparable organizations in the market, and experts’ opinions.

Validation of Framework and Methodology

Expert Edgar Blanco, Research Director for the MIT Center for Transportation & Logistics, and Executive Director for the MIT Supply Chain and Logistics Excellence (MIT SCALE) Network, discussed two research papers recently finished, together with his guided PhD thesis student, Yin Jin, on LCA in the Food Industry. The papers, titled “Streamlined Life Cycle Assessment of Carbon Footprint of a Tourist Food Menu Using Probabilistic Under Specification Methodology”, and “Streamlined Carbon Footprint Computation - A Case Study in The Food Industry”, acknowledge the uncertainty inherent to any attempt on measuring the carbon footprint or equivalent GHG emissions of a particular meal or food ingredient. Instead, they
group food ingredients into different categories (see Figure 1, below) and propose probabilistic models to deal with this uncertainty and to manage variability, categorizing each food group by possible carbon footprint or equivalent GHG emission value ranges that depend on the type of food, its origin and the technology used to produce it. Blanco thus stated that the presented methodology is valid, as long as it accounts for the mentioned factors.

Figure 1: Example of food groups [Jin Lee, et al, 2013] showing groups criteria, with the country of origin and technology being particularly important for meat and greenhouse-grown ingredients, respectively.

<table>
<thead>
<tr>
<th>Order of Impact</th>
<th>Food Group</th>
<th>Food</th>
<th>Specific food</th>
<th>Country of Origin</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Beef</td>
<td>Beef</td>
<td>Beef</td>
<td>Beef</td>
<td>Beef</td>
</tr>
<tr>
<td>2</td>
<td>Fish</td>
<td>Fish</td>
<td>Fish</td>
<td>Fish</td>
<td>Rice</td>
</tr>
<tr>
<td>3</td>
<td>Chicken</td>
<td>Beef tongue</td>
<td>Rice</td>
<td>Rice</td>
<td>Fish</td>
</tr>
<tr>
<td>4</td>
<td>Potato</td>
<td>Beef heart</td>
<td>Plant oil</td>
<td>Plant oil</td>
<td>Plant oil</td>
</tr>
<tr>
<td>5</td>
<td>Minced meat*</td>
<td>Beef liver</td>
<td>Parmesan cheese</td>
<td>Parmesan cheese</td>
<td>Sugarcane sugar</td>
</tr>
<tr>
<td>6</td>
<td>Sugarcane sugar</td>
<td>Rice</td>
<td>Tomato</td>
<td>Sugarcane sugar</td>
<td>Yogurt*</td>
</tr>
<tr>
<td>7</td>
<td>Yogurt*</td>
<td>Plant oil</td>
<td>Sugarcane sugar</td>
<td>Canned tuna</td>
<td>Parmesan cheese</td>
</tr>
<tr>
<td>8</td>
<td>Rice</td>
<td>Parmesan cheese</td>
<td>Canned tuna</td>
<td>Yogurt*</td>
<td>Canned tuna</td>
</tr>
<tr>
<td>9</td>
<td>Chicken egg</td>
<td>Tomato</td>
<td>Yogurt*</td>
<td>Shrimp</td>
<td>Shrimp</td>
</tr>
<tr>
<td>10</td>
<td>Canned tuna</td>
<td>Shrimp</td>
<td>Mozarella cheese</td>
<td>Mozarella cheese</td>
<td>Mozarella cheese</td>
</tr>
<tr>
<td>11</td>
<td>Yogurt*</td>
<td>Mozarella cheese</td>
<td>Tomato</td>
<td>Tomato</td>
<td>Tomato</td>
</tr>
<tr>
<td>12</td>
<td>Shrimp</td>
<td>Chicken eggs</td>
<td>Chicken</td>
<td>Zucchini</td>
<td>Zucchini</td>
</tr>
<tr>
<td>13</td>
<td>Mozarella cheese</td>
<td>Chicken</td>
<td>Zucchini</td>
<td>String bean*</td>
<td>String bean*</td>
</tr>
<tr>
<td>14</td>
<td>Zucchini</td>
<td>Zacchini</td>
<td>String bean*</td>
<td>Milons</td>
<td>String bean*</td>
</tr>
<tr>
<td>15</td>
<td>String bean*</td>
<td>String bean*</td>
<td>Flours</td>
<td>Flour</td>
<td>Flour</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td></td>
<td>Yellow cheese</td>
<td>Yellow cheese</td>
<td>Yellow cheese</td>
</tr>
<tr>
<td>17</td>
<td></td>
<td></td>
<td>Yellow cheese</td>
<td>Chicken eggs</td>
<td>Tomato fruit*</td>
</tr>
<tr>
<td>18</td>
<td></td>
<td></td>
<td></td>
<td>Watermelon</td>
<td></td>
</tr>
</tbody>
</table>

Table III. The lists of set of interest, the items that fall into the top 90% of the total food CF for more than 75% of the runs, for the five levels of specifications. The items that use other food CF surrogate data (e.g. Yogurt used Ice cream CF) are marked with *. The items that have interesting patterns in the list are shaded in grey.

In a similar fashion, expert Christina Ingersoll, Strategic Systems Integration Coordinator at the Committee on Sustainability Assessment (COSA), agreed on grouping food as an acceptable procedure to acknowledge for variability in equivalent GHG emissions. According to her, emissions for a particular food ingredient could vary as much as 100%, or even 1000%, depending on different variables across its value chain. Grouping makes sense when one may account for technology (greenhouse versus organic) and origin (particularly in the case of meat, due to grazing techniques), because these are the most critical components after the agricultural use of land (Figure 4).
Scope

Despite research about greenhouse gas emissions starting to gain momentum more than a decade ago, research related to the environmental impact of food seems to begin experiencing significant growth just in recent years. This evidence is corroborated by our conversations with academics and experts in the Cambridge area. Finding the full list of available evidence helped us narrow our search to the most recent works, and gives us confidence that we have considered the most relevant data.

Figure 2: Histogram of the number of articles mentioning “food” and “life cycle assessment” in recent years.


Production vs. Consumption Approach

The majority of historical literature about food Life Cycle Analysis (LCA) focuses on identifying opportunities to improve the efficiency in food production. There is abundant research focusing on production techniques to decrease GHG emissions by implementing new technologies, new products, and better practices. Research on enhancing the production scope of processing methods, and comparing traditional and industrial techniques has also been found. Other studies focus on the impact of the transportation and logistics that involves the international and domestic trade of food around the globe [Weber, et al., 2008]. In general terms, all the previous approaches focus on the environmental impact of the production side of the food industry.

Recently, it has been found that the production perspective has been evolving into a hybrid approach that considers dietary decisions as an additional area in which to run an LCA analysis. This means that we might consider the decisions people make about what to eat and the nutritional value of the food as variables that determine the environmental impact of our food stemming from dietary choices. In order to answer the requirement from Sproot we consider both approaches and rank types of food to generate impact and value scores among diet options.
Figure 3: Conceptual map showing the range of appropriate functional unit choices for differing food-related LCA research.


**Functional Unit**

Among different research approaches, it is key to understand the functional units that different authors use as a reference point to link the environmental impact with the physical food. The functional unit is very important for knowing to what extent the findings can be compared across studies. Intrinsically, the value and final objective of supplying food around the globe is to provide nutrients and calories. Therefore, the ideal functional unit to use should be nutritional and calorie based. We have found these units when studies cover comparables types of food that share a common nutritional element, e.g. proteins. Analyzing GHG emissions among types of meats, we have found comprehensive analysis concerning environmental impacts of beef, pork, poultry, etc, as sources of proteins. In studies that consider a broader range of food, generally fruits and vegetables, different authors use different units to reference product flow (weight or volume). When the objective is using LCA analysis by individual food in order to aggregate information for a menu, a useful unit is grams since any recipe can be broken down to grams of a given ingredient per gram of finished product.

**Breakdown of Food & Agriculture Emissions**

Understanding the source of emissions during the entire process of land use, production and in the supply chain is necessary to challenge and test our assumptions. There are several studies that address a piece of the process or focus in a determined geographical location. California Environmental Associates (CEA) has developed one of the most recent studies aimed at a comprehensive understanding of the GHG emissions in food supply and agriculture. CEA gathers information from many sources to get a global picture, and they recognize that there is a
high degree of uncertainty in the contribution of certain items such as deforestation, direct agricultural emissions, and post-production processes. This inaccuracy might account for up to 46% of upward deviation of the medium estimates. Nevertheless, we find the evidence important to conclude that the most relevant processes that explain over 80% of the carbon emissions are concentrated in the deforestation, peat loss and fire, in other words the most common, practically universal direct agriculture methods and on-farm production and pre-production.

With the objective of complementing and testing these conclusions with other sources, we discovered relevant findings regarding the contribution of transportation and delivery on the total GHG emissions of food consumed in the US. Taking into consideration the growing movements of organic and local food, the work of C. Weber and S. Matthews points out that the impact of the “food-miles” (long distance distribution) is limited to 11% or less of total GHG emissions relating to food. Local consumption and organic production techniques are important in terms of nutritional value, taste, sustainability externalities such as chemical use, etc, but shifts in dietary choices might account for a bigger impact than any change in food-miles.
Uncertainty and cost-effectiveness

The amount of time and effort that take to gather data for a LCA food analysis has been one of the newest concerns address by the last researches. TESCO, one of the biggest retailers in the world failed to its commitment to monitor and label the vegetable and other types of food available on its shelves because the low reliability of the GHG data despite the massive resources invested. In addition to the cost involved, there are so many organizations and countries that are involved in the supply chain of a meal, that is simply impossible to make them collaborate sharing information about their processes. There is recent research developed in MIT that actually suggest mechanisms to offset the uncertainty and lack of information, with different of grouping and statistical modeling. Based on the finding in this paper and in the broad literature about LCA analysis, we will propose a cost-efficient tool that can be applied to any meal.

![Figure 5: The hierarchy structure of tomato is used to demonstrate how specifications increase across the five levels of specification.](image)

*Source: Lee J.L; Yang X.; Blanco E.; Streamlined Life Cycle Assessment of CarbonFootprint of a Tourist Food Menu Using Probabilistic Underspecification Methodology. Center for Transportation and Logistics Department at the Massachusetts Institute of Technology, Cambridge, MA 02139 USA.*

High-Level Recommendations

- a. Sproot can identify a maximum impact/emission limit that is deemed acceptable
- b. Sproot then works within that limit to optimize nutrition, taste, etc
- c. Sproot will ensure that the company is minimizing its own emissions when purchasing/sourcing food by bundling orders, economizing on few shopping trips
- d. Sproot continues to refine the tool as time goes on, in order to improve accuracy
- e. Sproot offers customers meals with a Super-Low Footprint and meals with a Medium Footprint (or similar designation) so Sproot can drastically reduce
footprint for certain meals and segment the market to identify which customers want really low impact meals and serve them, without losing other customers

**Operating the Sproot Impact Tool**

Sproot currently operates a highly effective analytical approach to ensuring appropriate nutrition in its food. Each ingredient is meticulously examined in terms of its nutrient profile, and the sum total value from each item included in Sproot’s meals is quantified. Using this tool, Sproot’s management and chef team are able to quantify the precise amount of nutrition their meals are providing to children. This tool is shown below in Figure 6.

![Sproot Ingredient & Nutrition Management Tool](image)

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Sproot’s CEO tasked the Sloan team with constructing a similar quantitative module that will fit into the current nutrition tool and provide estimations of the greenhouse gas emissions and the impact of each ingredient that the company uses. This will allow the chefs and management team to not only ensure adequate nutrition is delivered through meals, but also ensure that the meals being served remain below an acceptable level of environmental footprint. The tool would allow the chef team three specific functionalities:

1. **Monitoring total meal footprint**: The chef team will be able to monitor the total meal footprint of meals comprised of various ingredients, and, as mentioned above, should a quantitative limit be defined by the management, they would be able to ensure that meals remain below a certain level of impact

2. **Substituting ingredients**: Ingredient substitutions would allow the chefs to exclude specific high impact ingredients and include lower impact ingredients, and the dataset and tool would allow for this to be done on a quantitative basis
3. **Identifying the high-impact ingredients:** While the Sproot team is aware that ingredients such as beef and pork have high environmental impacts, our analysis of the data also demonstrates that greenhouse-grown vegetables have three to four times the impact of field grown vegetables; this allows the Sproot chef team to moderate its use of off-season (i.e. greenhouse grown) vegetables.

The tool our team has constructed is in its final stage of development, and is being tested with Sproot’s CEO and outside experts. We used a 3-step approach to constructing a functional tool:

1. **Identifying data and data sources:** Given the scarcity and variability of data in the food impact field, the team collected data from multiple sources (over ten different sources and analyses were used); where feasible, simple averages of various data points for the same ingredients were used, e.g., we averaged the estimated GHG impacts we found for beef grown in the US, the UK and Ireland.

2. **Grouping ingredients:** Ingredients on the Sproot menu list were grouped bottom-up (similar ingredients such as various types of potatoes were grouped together) and then top-down in terms of the data availability; so for example, potatoes, leeks and squashes were grouped further, as the data for this group was only available en masse, and these vegetables share similar impact profiles.

3. **Creating a Red-Amber-Green rating system:** Finally, speaking to experts, the team created a directional rating system that we recommend Sproot use, given the difficulty of identifying specific values for ingredient impacts. This was constructed using relative “levels” and is given in a Red-Amber-Green framework.

The results from our tool are shown in Figure 5 below: a database has been constructed based on the data collected, and Sproot can identify the impact of each item. An ingredient calculator is also provided for the Sproot team, as shown in Figure 6.
## Conclusion

It is clear that even with a sophisticated understanding, high ideals, spreadsheets, and impact models, providing healthy and environmentally responsible meals is a monumental task in 21st century USA. Although advances in food science, agricultural practices, and processing techniques have helped resolve crippling problems such as starvation, malnutrition, spoilage, and food-borne biological pathogens, like weeds in a garden other problems have cropped up to take their place in causing harm both to direct consumers and to humanity as a whole. Illness such as pellagra has been eradicated from the US with niacin added to flour, and American goiters are a thing of the past thanks to iodine added to salt. Yet persistent food-related threats to health and wellbeing still exist and cannot be easily waved away. Thanks to Sproot and others that tackle these issues head-on, there are now options becoming more available to consumers that support good health and which reduce the destructive environmental impacts of our food system. As shown by our analysis, the most powerful lever we have to achieve these aims is in fact not changing where or how our food is produced, but what types of food we eat. Consuming less beef can have a huge effect in reducing environmental damage; indeed, consuming less animal

<table>
<thead>
<tr>
<th>Name of Group</th>
<th>Number of ingredients in group</th>
<th>Frequency of usage</th>
<th>GHGs (kg CO2 eq./kg food)</th>
<th>Team classification of impact (RAG Classification)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>8</td>
<td></td>
<td>29.25</td>
<td>Red</td>
</tr>
<tr>
<td>Cereals</td>
<td>43</td>
<td></td>
<td>0.71</td>
<td>Green</td>
</tr>
<tr>
<td>Dairy</td>
<td>24</td>
<td></td>
<td>3.63</td>
<td>Amber</td>
</tr>
<tr>
<td>Eggs</td>
<td>3</td>
<td></td>
<td>3.00</td>
<td>Amber</td>
</tr>
<tr>
<td>Fish</td>
<td>4</td>
<td></td>
<td>3.10</td>
<td>Amber</td>
</tr>
<tr>
<td>Fruit Group A</td>
<td>23</td>
<td></td>
<td>0.32</td>
<td>Green</td>
</tr>
<tr>
<td>Horticulture</td>
<td>44</td>
<td></td>
<td>0.19</td>
<td>Green</td>
</tr>
<tr>
<td>Lamb</td>
<td>1</td>
<td></td>
<td>25.67</td>
<td>Red</td>
</tr>
<tr>
<td>Legumes</td>
<td>30</td>
<td></td>
<td>0.75</td>
<td>Green</td>
</tr>
<tr>
<td>Pork products</td>
<td>4</td>
<td></td>
<td>8.20</td>
<td>Red</td>
</tr>
</tbody>
</table>

**Figure 7.a MIT Sloan Team Ingredient Impact Module**

**Figure 7.b MIT Sloan Team Ingredient Impact Calculator**
products of all kinds is likely the most significant way we can reduce impact. The tools produced through this project will aid Sproot in offering thoughtful, responsible, and healthy food to consumers. It is our hope that this trend will continue to spread, and that tools such as these will be made simple and easily available to consumers themselves, as well as to other businesses, to help guide the American and the global population toward eating habits that are more sustainable in the long term.
REFERENCES


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