Interim Report: Minimizing Carbon Footprint in Diet Plans

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11/10/2023

Problem Description

Food systems are responsible for around 26% of global greenhouse gas emissions. A critical challenge in environmental sustainability is identifying a diet that satisfies nutritional needs while minimizing environmental impact. This project aims to address this challenge by developing a weekly dietary plan that minimizes the carbon footprint associated with the diet while meeting recommended nutritional requirements as per the FDA guidelines, contributing to environmental sustainability while ensuring nutritional adequacy.

Data

For this analysis, we are leveraging data from multiple sources:

1. Environmental impact data of various foods, sourced from link.
2. Nutritional information dataset, available at link.
3. Dietary constraints based on FDA nutritional recommendations.

Methods

A mixed-integer optimization (MIO) problem is formulated to minimise the total carbon emissions associated with a diet, given by $c^T x$, where c is the total emissions resulting from the production of a gram of food i and x is the number of grams consumed of food i. This objective function is subject to constraints $\sum_{i=1}^{n} x_i y_j \geq R_j$, whereby the amounts of nutrients ($x \times y_j$, where y_j is the amount of nutrient j provided by a gram of food i) must be greater than the FDA's weekly nutritional recommendations for the nutrient j. The decision variable x_i is the quantity of each of 43 foods to consume in grams per week.

Expected Results

The optimized diet composition will provide a detailed weekly diet plan specifying the quantity of each of the 43 food items to be consumed (in grams per week), as well as the total carbon footprint of the optimized diet. This will hopefully show a significant reduction in CO2 emissions compared to typical diets in the USA and will allow for an estimation of potential environmental benefits, as well as health implications if such a diet were adopted widely. The following extensions may be attempted to add practical value to the project:

1. **Sensitivity Analysis:** Assessing how changes in certain parameters (e.g., the carbon footprint of specific foods, nutritional needs) affect the optimized diet. For instance:
   - How does an athlete's increased protein requirement impact their carbon footprint?
   - How do FDA nutritional guidelines correlate with environmental emissions and how could policy be adjusted to produce nutrient-rich foods more sustainably?
2. **Recipe Generator Input:** Integrating the project's findings into a recipe generator for practical dietary application.
3. **Scalability:** Analyzing the feasibility of implementing this diet plan on a broader scale by utilizing a food cost dataset to define budgetary constraints.