Title
Beef to Bean: An Analysis of the Environmental Benefits of Replacing Beef with Bean Dishes

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Beef to Beans: An Analysis of the Environmental Benefits of Replacing Beef with Bean Dishes in K-12 Schools

A thesis submitted in partial satisfaction of the requirements for the degree Master of Science in Civil Engineering

by

Tannis Breure

2023

ABSTRACT OF THE THESIS

Beef to Beans: An Analysis of the Environmental Benefits of Replacing Beef with Bean Dishes in K-12 Schools

by

Tannis Breure

Master of Science in Civil Engineering

University of California, Los Angeles, 2023

Professor Jennifer Ayla Jay, Chair

Research has shown that a shift in dietary patterns towards a more plant-rich diet is required to meet climate targets. One method of mitigating our carbon footprint is to replace beef with beans in K-12 lunches. Real sample menus from school districts throughout the US were used to determine the environmental strain caused by beef as the default option in schools. This limited study considered the following metrics: environmental health, land and water use, financial impacts, and cultural benefits. The results determined that replacing beef with beans in school lunches can provide benefits across each of these factors particularly in emission reduction associated with bean production. By making the substitution of beef for beans, schools can contribute to climate goals and promote sustainable eating habits while also providing students with a nutritious meal.

The thesis of Tannis Breure is approved.

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University of California, Los Angeles

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INTRODUCTION

In recent years, there has been an increased focus on the environmental impact of our food choices. In particular, the livestock industry is one of the leading causes of greenhouse gas emissions, deforestation, water and air pollution, and soil degradation (Richter et al., 2020). At present, livestock accounts for 27% of the technical greenhouse gas emissions (GHG) mitigation potential of the United States (US EPA, 2023). As the global demand for beef increases, large-scale industrialized livestock production has increased in response to growing population. This expansion of beef production is mostly concentrated in countries with less stringent environmental and health regulations, and this spatial distribution disproportionately affects community health in those areas. To meet our sustainability goals, a shift toward less meat in the A is imperative (FAO, 2022; Clark et al. 2020; Springmann et al. 2018).

In order to meet GHG emission targets, there is growing interest in plant-based diets as a sustainable and healthy alternative to traditional meat-centered diets. One mitigation strategy is to encourage and implement plant-based diets and behaviors in K-12 schools. This strategy has been studied in higher education institutions (HEI) and shown to potentially decrease GHG emissions by on-third (Lambrecht et al., 2023). At present, the United States Department of Agriculture (USDA) provides school lunch programs to over 30 million students each day in K-12 schools. The school lunch program plays a critical role in providing healthy meals to children, many of whom may not have access to nutritious food at home. However, traditional school lunches often lack diversity and rely heavily on processed foods, including meat products like beef, which are associated with negative health and environmental impacts. By influencing the nutritional behavior of students at a young age, there is an increased likelihood that those behaviors will continue into adulthood (HHS, 2021).

One plant-based food group that has gained significant attention is legumes, and in particular, beans. This interest is rooted in the desire to improve the health of students, as beans are a nutrient-dense and affordable source of protein, fiber, and other essential nutrients, making them an ideal addition to school lunch menus. Furthermore, it is also motivated from an environmental standpoint, beans have a drastically lower environmental footprint compared to beef, making them an attractive alternative for reducing greenhouse gas emissions and promoting sustainable food systems while uplifting minority cultures in the US.

Harwatt et al. (2017) modeled the environmental impacts in terms of GHG production of switching out beef for beans in the U.S. diet. They found that the GHG savings from replacing beef with beans would amount to between 46 and 74% of the reduction needed for the U.S. to meet the Paris Climate Accord target. Recognizing the disproportionate environmental impacts of beef, Eshel et al. (2016) used linear programming to optimize which foods would best replace beef in the U.S. diet, both in terms of nutritional value and environmental impact. They found that beans and peanuts were the primary foods in the replacement diets that the model proposed, and that this replacement would result in 74% fewer GHG emissions, 42% less land use, and less reactive nitrogen use.

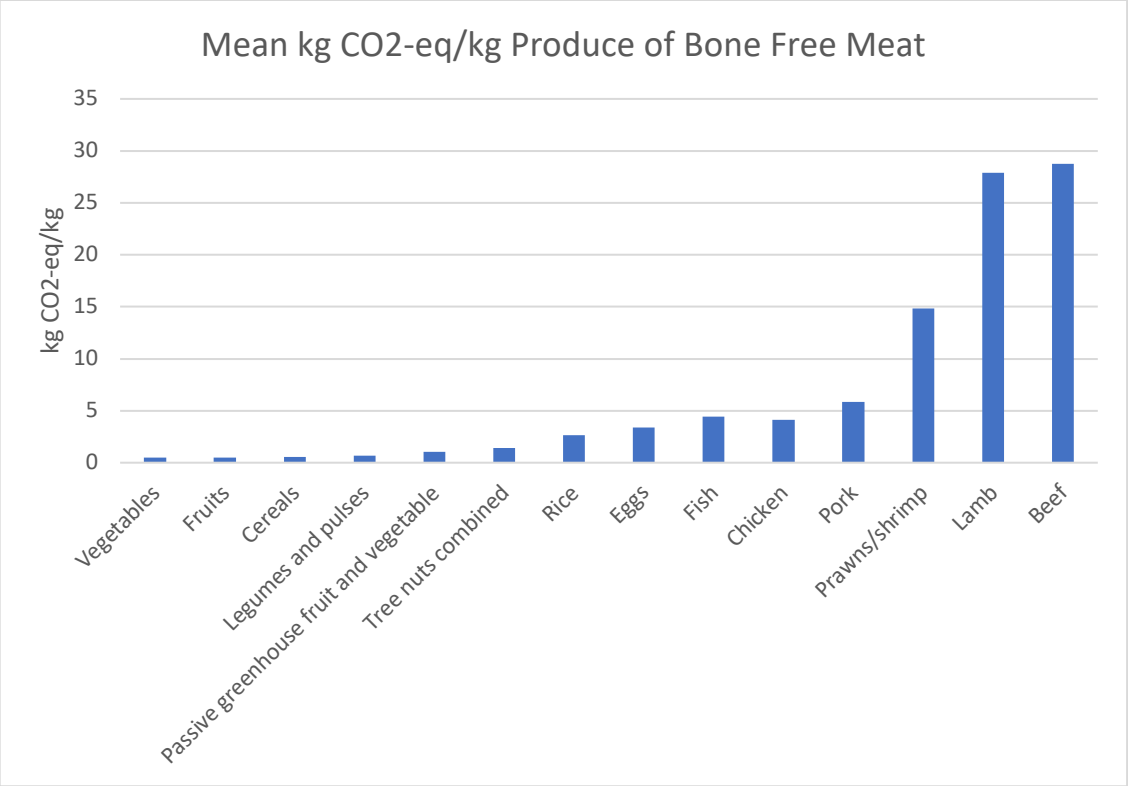

Figure 1. Mean *kg CO2e/kg* values of broad food categories

The aim of this paper is to review the current scientific evidence on the environmental and health benefits of replacing beef with beans in the diet. The environmental impact of beef production will be examined and compared to that of beans on the basis of land and water use, carbon emissions, and cost efficiency. The potential health benefits of a plant-based diet will also be mentioned, with a particular focus on the role of beans in promoting health and preventing chronic diseases to alleviate the strain on the US healthcare system (Clem & Barthel, 2021).

This paper seeks to highlight the importance of shifting away from beef consumption towards more sustainable and healthy dietary options such as beans. However, the seemingly simple bean alternative to beef is not intended to undermine the monumental societal changes that must occur in order to achieve GHG reduction targets. Ideally, we can reduce the negative

impact of the livestock industry on the environment and promote better health outcomes for individuals and communities throughout the United States while meeting these ambitious targets (Willett et al., 2019).

METHODS

SEARCH METHODS

The protocol used to conduct this literature review was to search for academic articles in scientific databases for engineering fields concerning the topic, then select the most relevant manuscripts for further analysis and discussion of their main aspects and findings. The following parameters were used:

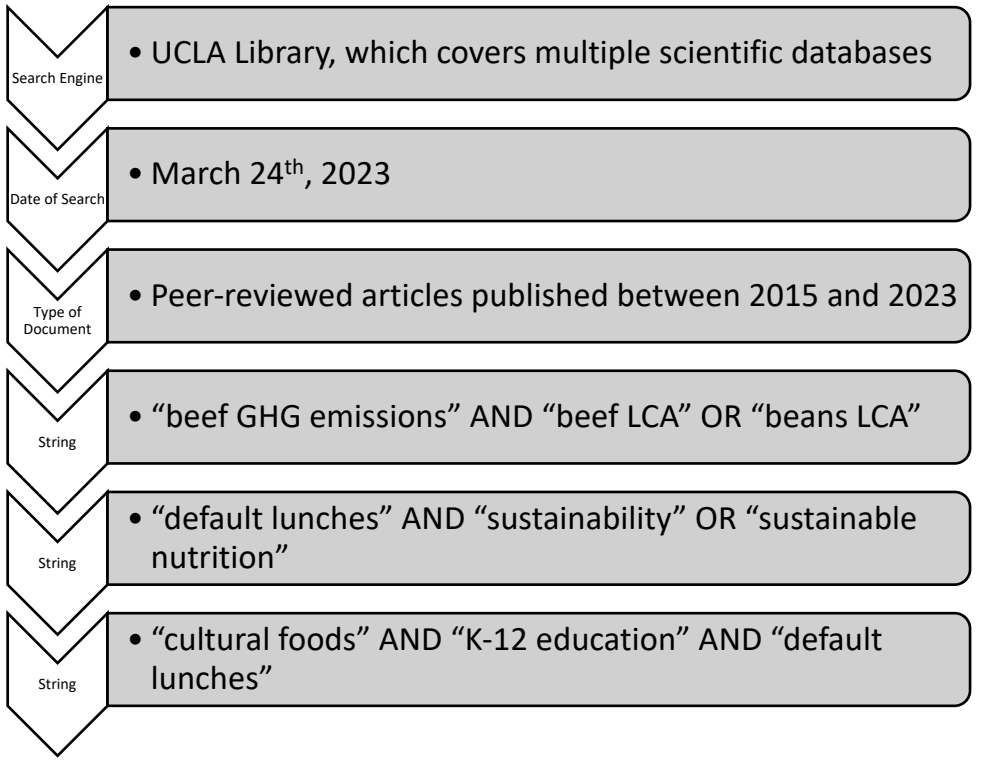

Figure 2. *Search methods using UCLA library*

The search terms noted in Figure 2 yielded 1,708 research articles. Of the 1,708 research articles, 1,129 were peer-reviewed and chosen for preliminary assessment for further use in this study. The search was further narrowed down to agriculture in the United States and nutritional studies performed in K-12 schools nationwide. Additional internet searches were performed to determine specific nutritional standards and requirements at a federal level that are otherwise not searchable within the UCLA library.

POLICY AND MEETING CLIMATE TARGETS

A report by the Center for Sustainable Systems at the University of Michigan explored how different dietary scenarios may impact greenhouse gas emissions in the United States in the year 2030 (Heller et al., 2020). The study compared three different scenarios: a business-as-usual scenario where the US diet remains unchanged, a scenario where the populace adopts a healthy US-style diet based on recommended dietary guidelines, and a scenario where they adopt a plant-based diet. The study found that a shift towards a healthy US-style diet could result in a 27% reduction in greenhouse gas emissions, while a shift towards a plant-based diet could result in a 70% reduction in greenhouse gas emissions. This article not only highlights the importance of considering the environmental impact of our dietary choices, but also suggest that policies and programs that promote healthier and more sustainable diets could mitigate climate change more than originally anticipated.

The article "Country-specific dietary shifts to mitigate climate and water crises" explores the potential impact of dietary shifts on reducing greenhouse gas emissions and water use in ten countries: Brazil, China, Ethiopia, India, Indonesia, Mexico, Nigeria, South Africa, the United Kingdom, and the United States. The study used a modeling approach to identify specific dietary

changes that could reduce greenhouse gas emissions and water use in each country, while also considering the health implications of those changes (Kim et al., 2020). The study also found that shifting towards plant-based diets could have significant environmental benefits, particularly in countries with high levels of meat consumption. However, the study also notes that cultural and economic factors must be considered when promoting dietary changes, and that a one-size-fits-all approach may not be effective. The study concludes that targeted policies and education campaigns that consider the unique contexts of each country are necessary to promote sustainable and healthy dietary shifts.

New York City is home to the largest school system in the United States at 1.1 million students, making it the perfect case study for implementing a meatless option for students. New York City began a Meatless Monday initiative in its public schools in 2019. This initiative encouraged students to choose vegetarian options for their Monday school lunches rather than the prior default meat option, with the goal of promoting healthier and more sustainable food choices. The program was launched by Mayor Bill de Blasio, who cited the environmental benefits of reducing meat consumption as well as the potential health benefits for students as the motivation of this initiative (Hopkins, 2020). Meatless Monday was initially launched as a pilot program in 15 Brooklyn schools in the spring of 2018, before expanding across all public schools city-wide in the fall of 2019. The program received positive feedback from many parents and students, but also faced some criticism and resistance from families who preferred to have meat options available every day. The Meatless Monday initiative in New York City public schools did not result in a formal policy change, but rather served as a voluntary program to encourage students to choose vegetarian options for their Monday school lunches. The program did not require schools to eliminate meat entirely from their menus, but rather offered plant-based

options as an alternative. The initiative was part of a broader effort by the city to promote healthier and more sustainable food choices, but it did not result in a formal policy change beyond the implementation of the program itself. This case can be used as a blueprint for other school districts to implement more robust school lunch intervention strategies to combat climate change and influence the nutritional behavior of students.

While the NYC Meatless Monday initiative did not result in direct policy changes, the USDA has recently proposed new standards that would allow students to have more flexibility in vegetarian choices and the opportunity to increase cultural awareness as more options are available (USDA, 2023). However, these standards are not currently in effect but are merely K-12 propositions for future meal planning. One such example is the Nuts and Seeds Provision. At present, the provision states that "Nuts and seeds can be served as a meat/meat alternate, but only credit towards 50% of the component at breakfast, lunch, and supper, and must be served alongside another meat/meat alternate". The proposed amendment to this provision would instead allow nuts and seeds to be credited for 100% of the meat/meat alternate component in all child nutrition programs and meals. By adopting more culturally inclusive provisions, students could develop tolerance and appreciation for cultures other than their own.

New York has not been the only state with robust climate goals. California has set ambitious greenhouse gas reduction targets through its landmark climate policies (Newsom, 2022), including:

1. 40% reduction in greenhouse gas emissions below 1990 levels by 2030.
2. Achieving carbon neutrality by 2045, which means that the state will remove as much carbon dioxide from the atmosphere as it emits.

3. Long-term goal of reducing greenhouse gas emissions to 85% below 1990 levels by 2045.

The state has also implemented a comprehensive suite of policies to achieve these targets, including a cap-and-trade program, renewable portfolio standards, energy efficiency standards, and incentives for electric vehicles and other clean technologies. These policies are designed to reduce emissions across all sectors of the economy, including transportation, buildings, industry, and agriculture. By replacing beef with beans in school lunches, three of the aforementioned sectors are directly and indirectly affected: the economy, transportation, and of course, agriculture.

QUANTIFYING EMISSION REDUCTION, ONE MEAL AT A TIME

Meeting GHG targets compliant with the Paris Climate Agreement is no small feat, but by starting in K-12 schools, a substantial decrease in CO2 emissions could be achieved. One possible way to model this is by calculating the carbon emission, land, and water use reductions by replacing beef with beans in currently served lunches throughout the United States. Thus, example recipes from Long Beach, CA, Chicago, IL and Austin, TX were used to calculate theoretical emission reduction. Five recipes were chosen to simulate a full week of lunches for students. According to the 2022 US census, 40.2% of the Long Beach student body identifies as Hispanic. Similarly, Chicago is 46.5% Hispanic while Austin has a population that is 55% Hispanic (US Census Bureau, 2022). Therefore, this list encompasses traditional food from prevalent Hispanic cultures in these major cities as well as a traditional American food, the hamburger.

Table 1. House-Made Beef Tostada Recipe

Ingredient	**Amount** (g)	**Vitamin A** (IU)	**Vitamin C** (mg)	**Protein** (g)	**Fiber** (g)
2 Corn Tortilla	51.6	0	0	4	2
2 Slices of Cheddar Cheese	56	599.8	0	14	0
Pico de gallo salsa	40	285.6	6.8	0	0
Beef	120	7.2	0	24	0
Beans	61	3.7	0	5.4	5.3
Kcal	624	-	-	-	-

Table 2. House-Made Beef Tostada Recipe, Bean Replacement

Ingredient	**Amount** (g)	**Vitamin A** (IU)	**Vitamin C** (mg)	**Protein** (g)	**Fiber** (g)
2 Corn Tortilla	51.6	0	0	4	2
2 Slices of Cheddar Cheese	56	599.8	0	14	0
Pico de gallo salsa	40	285.6	6.8	0	0
Beans	260	15.6	0	23	22.6
Kcal	772	-	-	-	-

Table 3. Beef Quesadilla Recipe

Ingredient	**Amount** (g)	**Vitamin A** (IU)	**Vitamin C** (mg)	**Protein** (g)	**Fiber** (g)
2 Corn Tortilla	51.6	0	0	4	2
2 Slices of Cheddar Cheese	56	599.8	0	14	0
Pico de gallo salsa	40	285.6	6.8	0	0
Beef	120	7.2	0	24	0
Kcal	552	-	-	-	-

Table 4. Beef Quesadilla Recipe, Bean Replacement

Ingredient	**Amount** (g)	**Vitamin A** (IU)	**Vitamin C** (mg)	**Protein** (g)	**Fiber** (g)
2 Corn Tortilla	51.6	0	0	4	2
2 Slices of Cheddar Cheese	56	599.8	0	14	0
Pico de gallo salsa	40	285.6	6.8	0	0
Beans	250	15.6	0	22	21.8
Kcal	717	-	-	-	-

Table 5. Hamburger Recipe

Ingredient	**Amount** (g)	**Vitamin A** (IU)	**Vitamin C** (mg)	**Protein** (g)	**Fiber** (g)
Beef	170	10.2	0	35	0
Olive Oil	7.5	N/A	N/A	N/A	N/A
Bread	100	0	0	10.2	4.1
Lettuce	15	401.9	3.2	0	0.3
Tomato	20	166.6	2.7	0.2	0.2
Kcal	552	-	-	-	-

Table 6. Hamburger Recipe, Bean Replacement

Ingredient	**Amount** (g)	**Vitamin A** (IU)	**Vitamin C** (mg)	**Protein** (g)	**Fiber** (g)
Beans	375	22.5	0	33.2	32.6
Olive Oil	7.5	N/A	N/A	N/A	N/A
Bread	100	0	0	10.2	4.1
Lettuce	15	401.9	3.2	0	.3
Tomato	20	166.6	2.7	0.2	0.2
Kcal	814	-	-	-	-

Table 7. Beef Enchilada Recipe

Ingredient	**Amount** (g)	**Vitamin A** (IU)	**Vitamin C** (mg)	**Protein** (g)	**Fiber** (g)
2 Corn Tortilla	51.6	0	0	4	2
Slice of Cheddar Cheese	28	299.9	0	7	0
Olive Oil	15	N/A	N/A	N/A	N/A
Beef	85	5.1	0	17.5	0
Tomato	70	583.1	9.6	0.6	0.8
Sour Cream	30	130.8	0.3	2.1	0
Kcal	579	-	-	-	-

Table 8. Beef Enchilada Recipe, Bean Replacement

Ingredient	**Amount** (g)	**Vitamin A** (IU)	**Vitamin C** (mg)	**Protein** (g)	**Fiber** (g)
2 Corn Tortilla	51.6	0	0	4	2
Slice of Cheddar Cheese	28	299.9	0	7	0
Olive Oil	15	N/A	N/A	N/A	N/A
Beans	195	11.7	0	17.3	17
Tomato	70	583.1	9.6	0.6	0.8
Sour Cream	30	130.8	0.3	2.1	0
Kcal	727	-	-	-	-

Table 9. Fiestada Taco Pocket Recipe

Ingredient	**Amount** (g)	**Vitamin A** (IU)	**Vitamin C** (mg)	**Protein** (g)	**Fiber** (g)
2 Corn Tortilla	51.6	0	0	4	2
Mozzarella Cheese	28	189.3	0	6.2	0
Lettuce	15	401.9	3.2	0	.3
Tomato	61.5	512.3	8.4	0.5	0
Olive Oil	15	N/A	N/A	N/A	N/A
Beans	61	3.7	0	5.4	5.3
Beef	85	5.1	0	17.5	0
Kcal	580	-	-	-	-

Table 10. Fiestada Taco Pocket Recipe, Bean Replacement

Ingredient	**Amount** (g)	**Vitamin A** (IU)	**Vitamin C** (mg)	**Protein** (g)	**Fiber** (g)
2 Corn Tortilla	51.6	0	0	4	2
Mozzarella Cheese	28	189.3	0	6.2	0
Lettuce	15	401.9	3.2	0	.3
Tomato	61.5	512.3	8.4	0.5	0
Olive Oil	15	N/A	N/A	N/A	N/A
Beans	250	15	0	22.2	21.8
Kcal	714	-	-	-	-

The strongest nutritional impacts of replacing beef with beans to match protein content in meals are an increase in fiber content, an increase in vitamin A and an increase in overall calories. One method to decrease caloric intake is by focusing on macronutrients other than protein and include fiber goals in K-12 schools. Currently, the recommended protein intake for children is 50 g and the recommended fiber intake is 28 g based on the reference intake of 2,000 calories (FDA, 2023). While there have been great advancements in dietary research in recent years, one constant factor that directly contributes to children's health and lowers their risk of type 2 diabetes is increased dietary fiber (Kranz et al., 2012). Therefore, the Dietary Reference Intake (DRI) suggests an increase in overall dietary fiber consumption in children and adults to mitigate overall health risks without increasing the likelihood of obesity (NIH, 2023).

CALCULATIONS

Utilizing the above example menu, the overall CO2 savings from a week of meals is 14,670 g CO2. Each bean replacement was calculated to match the protein requirements of the respective default beef per gram and the relative CO2 values were taken from the USDA master database and greenhouse gas emissions of US dietary choices (Heller, 2014). CO2 persists in the atmosphere longer than methane and produces long-lasting climate defects. All GHG emissions are of great importance to the global climate crisis, however, carbon dioxide is the focus of most studies and climate targets and other GHGs are written in terms of CO2 equivalence (NOAA, 2022).

Table 11. CO2 Savings per Serving

	Beef (g CO2/serving)	Beans (g CO2/serving)	CO2 Savings
Tostada	2,615	360	2,255
Quesadilla	4,033	784	3,249
Hamburger	4,950	362	4,588
Enchilada	2,841	556	2,285
Fiestada	2,566	273	2,293

The caloric equivalence ratio of substituting beans for beef as determined by Harwatt et al. is 0.97 and the protein mass ratio is 0.66. This was determined using values obtained from USDA nutritional information on beans and beef at their raw weights. 332 beef kcals divided by 341 bean kcals, and the protein mass ratio is 0.66 (14.4 g beef protein divided by 21.6 g bean protein). However, these values can vary greatly depending on the origin of the beef as well as the type of beans.

By using standard values from the USDA database, the Harwatt calculations can provide a blueprint for CO2 savings calculations. The simple replacement of beef for black beans, at the same protein intake, is a 221 calorie difference, an increase of 24 g of fiber, and 3,322 g CO2/per 150 g serving savings. Therefore, incorporating this change to the 4.9 billion lunches served annually in US schools, assuming beef is served half the time, the overall CO2 savings equates to $8.14\ x\ 10^{12} g$ of CO2 per year, or approximately 9 million tons.

CO2 savings if half of beef meals served were replaced with beans:

$$3{,}322\ g\ CO2 *\ 2.45 * 10^{9}\ =\ 8.14 * 10^{9}\ g\ or\ 9{,}149{,}183\ tons$$

It is forecasted that the mean cost of CO2 emitted into the atmosphere is $182/ton, an increase from the originally forecasted $51/ton (Rennert et al., 2022). The replacement of beef with beans in school lunches, assuming beef is served every other meal, would result in a $1.67 billion annual savings from the CO2 not emitted into the atmosphere.

Comparatively, Harwatt et al. utilized the following calculations to determine the overall energy and protein equivalence factors of replacing beef with beans:

US emissions, energy equivalence: 40.2 kg CO2e/kg—(0.8 kg CO2e/kg ×0.97) = 39.4 kg CO2e/kg

US emissions, protein equivalence: 40.2 kg CO2e/kg—(0.8 kg CO2e/kg ×0.66) = 39.7 kg CO2e/kg

Global emissions, energy equivalence: 25.5 kg CO2e/kg—(1.1 kg CO2e/kg ×0.97) = 24.4 kg CO2e/kg

Global emissions, protein equivalence: 25.5 kg CO2e/kg—(1.1 kg CO2e/kg ×0.66) = 24.8 kg CO2e/kg

Applying the above equations to our example menu, the following values were obtained based on all protein provided by the default beef being replaced by equivalent bean protein:

Table 12. Energy and Protein Equivalent CO2/kg Using Harwatt Calculations

Recipe	**Beef (g)**	**Energy (kg CO2e/kg)**	**Protein (kg CO2e/kg)**
Tostada	120	4728	4764
Quesadilla	120	4728	4764
Hamburger	170	6698	6749
Enchilada	85	3349	3374.5
Fiestada Taco Pocket	85	3349	3374.5

While these values differ slightly from those in Table 11, it is due to values used in the Harwatt calculations which was calculated as a median value of 40.2 kg CO2e/kg for US emissions standards from various US Life Cycle Assessments (LCA).

IMPACTS ON WATER AND LAND USE

In addition to the health benefits, replacing beef with beans can also have significant sustainability impacts. Cattle raised for beef require large amounts of water, land, and feed, contributing to greenhouse gas emissions and environmental degradation (Richter et al., 2020). The intensive production of beef has also been shown to contribute to water scarcity and fish imperilment as these According to the United Nations Food and Agriculture Organization, beef production is responsible for around 14.5% of global greenhouse gas emissions. In contrast,

beans require significantly less water and land to grow and produce fewer greenhouse gas emissions.

Westhoek et al. found that beef production contributes significantly to greenhouse gas emissions and environmental degradation, primarily due to land use and feed production. In contrast, bean production has a much lower environmental impact, requiring less land, water, and fertilizer. The authors suggest that if Americans replaced beef with beans, the US could reduce its greenhouse gas emissions by 48-74%, depending on the extent of substitution. Cropland would also increase with a reduction of beef production, particularly in the Midwest and allow land to rewild (Eshel et al., 2016). Similarly, Harwatt et al., reported the same findings and noted that this replacement could free up 42% of US cropland necessary to meet 2020 US climate goals. However, it is important to note that these estimates are for past goals, while future goals are more robust and require further updated calculations to reflect new benchmarks.

The following water and land use were calculated using global average footprints (Mekonnen & Hoekstra, 2011) associated with each recipe:

Table 13. House-Made Beef Tostada Recipe Water and Land Use

Beef		**Bean**	
Water (L)	Land (m^2)	Water (L)	Land (m^2)
0.1802254	12.462689	0.1306324	1.791649

Table 14. Beef Quesadilla Recipe Water and Land Use

Beef		**Bean**	
Water (L)	Land (m^2)	Water (L)	Land (m^2)
0.0962208	16.897784	0.0644708	1.707784

Table 15. Hamburger Recipe Water and Land Use

Beef		**Bean**	
Water (L)	Land (m^2)	Water (L)	Land (m^2)
0.127875	23.5306	0.08575	2.0956

Table 16. Beef Enchilada Recipe Water and Land Use

Beef		**Bean**	
Water (L)	Land (m^2)	Water (L)	Land (m^2)
0.1774804	12.408984	0.142375	1.741984

Table 17. Fiestada Taco Pocket Recipe

Beef		**Bean**	
Water (L)	Land (m^2)	Water (L)	Land (m^2)
0.1512254	12.363689	0.1016324	1.652249

On average, the sample recipes all have a decreased land use footprint when beef is replaced by beans. Unsurprisingly, bean production also utilizes less liters of water by a significant margin in each scenario. This is due to the production of beef requiring significantly more land per pound, making plant-based replacements 25-44% more advantageous for climate change adaptation strategies (Saget et al., 2021).

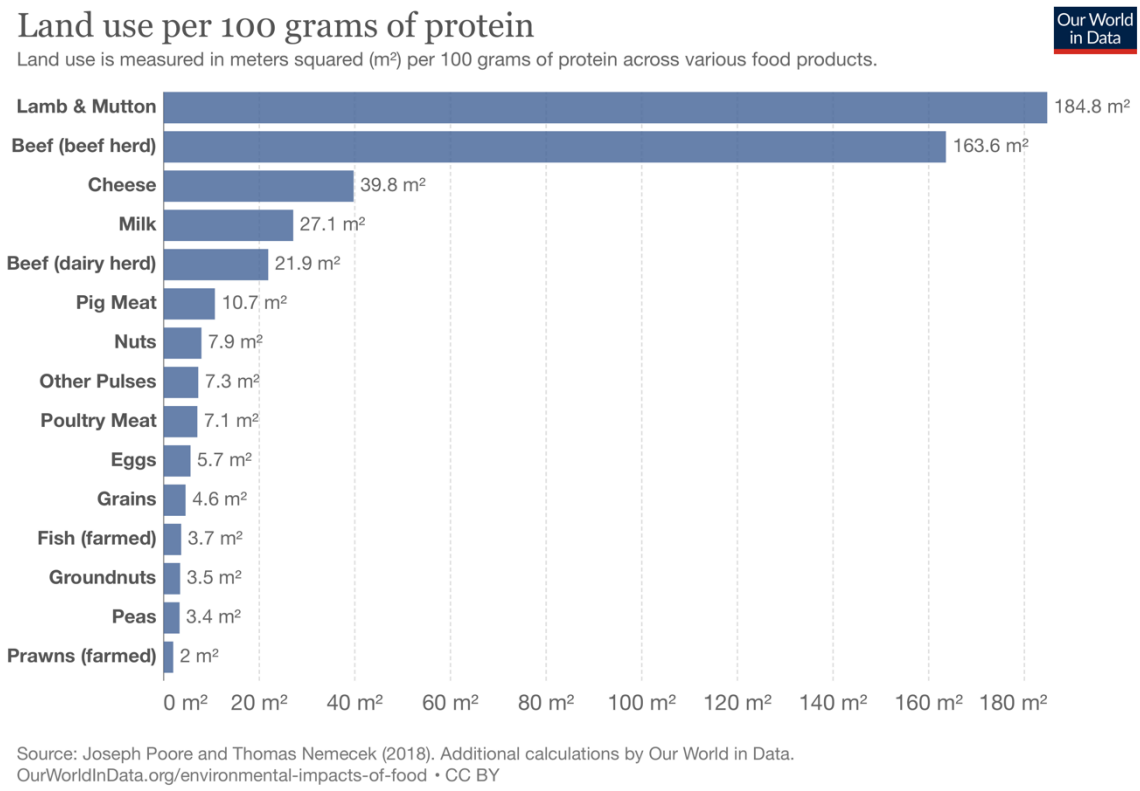

Figure 3. Land Use per 100 g of Protein for Common Beef Replacements (Poore, 2018)

More broadly, alternative forms of protein have consistently lower land usage than beef. Figure 3 illustrates the vast disparity of land use per gram of protein for beef when compared to other animal-derived products and plant-based protein alternatives like tofu (soybeans). When examining this metric, it is also important to consider the average serving sizes of each as well as the macro and micronutrients necessary to not only meet our climate goals but also our health goals as a nation (OASH, 2023).

TRANSPORTATION

According to a study by the University of Michigan, beef production and transportation account for 5.7 kg CO2e per 100 grams of beef consumed. This includes emissions from livestock production, feed production and transportation, and meat processing and transportation.

In contrast, bean production and transportation emit only 0.5 kg CO2e per 100 grams of beans consumed. Astoundingly, if all Americans replaced beef with beans once a week, they would reduce transportation emissions by 6.5 million metric tons of CO2e per year.

Replacing beef with beans in K-12 diets can have a substantial impact on transportation related emissions. If an individual replaces 100 grams of beef with 100 grams of beans, one could potentially reduce transportation emissions by 5.2 kg CO2e. This is a significant emissions reduction, especially when considering the global consumption of beef. Furthermore, beans can be grown locally, reducing transportation emissions and supporting local farmers. Future works should explore the idea of including locally grown beans into school lunches, allowing students to learn about the importance of sustainable agriculture and the environmental benefits of consuming plant-based foods. They can also develop a connection with their local food system and learn about the other cultures prevalent in their schools and beyond.

NUTRITION

In addition to environmental impacts, it would be remiss not to mention the nutritional advantages of replacing beef with beans in K-12 schools. Red meat is classified as a Group 2A carcinogen and evidence suggests a particularly strong link with colorectal cancer, pancreatic cancer, and prostate cancer (WHO, 2015). Contrastingly, an increase in vegetable consumption is associated with lower rates of childhood obesity. Converting to a plant-based diet at a young age and educating K-12 on the importance of nutrition would greatly mitigate these risks even into adulthood (HHS, 2021).

Replacing beef with beans in school lunches can bring numerous benefits for students, their health, and the environment. Firstly, beans are an excellent source of protein, making them a healthy substitute for beef. They contain all the essential amino acids required for growth and development, making them a complete protein source. Beans also have the benefit of being rich in fiber, which can help students feel full and satisfied throughout the day, improving their concentration and reducing their risk of developing chronic diseases. By incorporating beans into school lunches, students can benefit from the nutritional value of beans, without the negative impact on their health that is often associated with beef (Islam, 2019).

ETHICAL TREATMENT OF ANIMALS

Modern farming methods present serious issues regarding the ethical treatment of animals (Hampton et al., 2021). Unfortunately, farm animals are exempted from all federal laws concerning animal welfare, even though conditions on factory farms and slaughterhouses would not be considered humane for companion animals. Animal cruelty in cattle farming is a distressing reality that raises ethical concerns about the treatment of livestock. According to a study in the Journal of Animal Science (2020), space, handling, and stunning are all major concerns that are audited in North American slaughterhouses, but many are not meeting standards. Even most cattle who are raised on pastures for much of their lives spend the last portion of their lives in crowded feedlots for “finishing”. These cruel practices not only compromise the welfare of the animals but also raise questions about the standards and regulations in place. Addressing the issue of animal cruelty in cattle farming requires a comprehensive approach that promotes animal welfare, encourages responsible farming practices, and advocates for stricter enforcement of regulations.

Even when comparing confined animal feeding operations (CAFOs), which are less water and land intensive than traditional farming (Capper, 2012), beef consumption is less environmentally friendly than a plant-based replacement when considering all factors (Ritchie, 2020). Furthermore, only focusing on the emissions produced by cattle farming would undermine the other issues in our unprecedented ecological crisis. Rather than viewing animals as manipulable only for human consumption, a systems approach should be taken by policy holders to consider the lives of animals as well. Whether it be in a feed lot or free-range, the unfair treatment, environmental consequences, emissions produced from these processes are not communicated to consumers.

Habitat destruction caused by the implementation of CAFOs is also an imperative topic when looking at the system of sustainable food and diet. Not only does the farming of beef harm cows, but it is also often detrimental to other animals and the future of other species. Feed lots in particular are known to contribute negatively to air quality (CDC, 2023), surface and groundwater water quality, and can leach antibiotics and other contaminants into marine ecosystems (Burkholder et al., 2007). In addition, climate change will exacerbate the harsh conditions animals face on factory farms and in transit.

EDUCATION AND CULTURAL BENEFITS

Hedenus et al., also considered three scenarios to reduce GHG emissions: improving productivity in the livestock sector, technical mitigation measures, and human dietary changes. The long-term results from this study estimate that 3-5 Gton CO2eq/yr can be reduced by the year 2070 if humans shift 75% of the meat in their diet to plant-based foods. These values were calculated by considering a reduction in both meat and dairy, and the author notes that these

reductions are crucial to staying below the 2°C limit of warming (IPCC, 2020). These findings, however, undermine the cultural importance of meat in various regions.

In some countries, beef has become an integral part of society. In the journal of Food, Culture, and Society, Lapegna et al., explored the historical and social factors that have shaped the importance of beef in Argentine cuisine, as well as the economic and political dimensions of the beef industry in Argentina. The article argues that beef has become a symbol of Argentine identity and national pride, and that its cultural significance extends beyond food and eating habits to encompass a wide range of social and political issues. This research provides a detailed and nuanced analysis of the cultural significance of beef in Argentina and highlights the complex ways in which food and culture are intertwined (Lapegna et al., 2011). While the United States is home to many other cultures, Argentina can provide insight into the depth of cultural significance that beef holds to many people living in the US.

Moreover, beef is not the only culturally significant food, and beans also play a critical role in the development of culture and society in a wide variety of people. For many, cows are a protected species and hold high value in religions like Hinduism, Janaism, African Paganism, and Buddhism. The religions also heavily rely on legumes for sustenance and have for thousands of years. Once considered a staple food for peasants, beans have seen a resurrection in gastronomy and are critical to many traditional dishes worldwide (Corrado, 2022). By incorporating beans into lunches, the opportunity to celebrate a multitude of cultures is abundant.

Food education has been shown to inspire new “eating at home” habits that extend beyond the classroom (Hansen et al., 2019; Chen et al., 2009). The introduction of default vegetarian lunches in K-12 schools can act as a catalyst for transforming eating habits when

students are consistently exposed to alternative meal options. One major benefit of implementing this practice is the potential ripple effect that could bring about a broader shift towards healthier eating within households that may be food insecure or lack the foundational knowledge on nutrition. In theory, this could help future generations continue these more sustainable eating practices and eventually decrease the risk of epidemics such as cancer and obesity in the United States (WHO, 2023).

FOOD WASTE AND ECONOMIC BENEFITS

Sustainable management of food plays an integral part of addressing climate change, increasing food security and economic efficiency while simultaneously conserving energy and precious resources (EPA, 2023). According to the EPA, the United States discards approximately 40 million tons of food per year, more food than any other country. This equates to 30-40% of the US food supply. One method to reduce food waste is by replacing perishable items with non-perishable food items such as beef with beans since beans have a longer shelf life and are less perishable than beef, which can help reduce food waste and related costs. In addition to the reduction of environmental impact of food waste, this can function as a way of saving money for schools.

Quantitatively, the benefits of beans as a replacement for beef are not only environmental; replacing beef with beans can also have economic benefits. Beans are generally less expensive than beef, making them a more affordable option for schools. This can lead to a reduction in the overall cost of school lunches, and consequently an increase in accessibility for students from lower-income families.

For the same protein intake, beans cost $0.70 less than beef at national pricing (USDA, 2015).

$$Beef: \$.011/g * 120\ g = \$1.27$$

$$Beans: \$.004/g * 150\ g = \$0.57$$

This serving specific reduction could result in millions of dollars saved annually if applied across all school districts in the United States. Assuming 40 million students consume a conservative estimate of 120 g beef/week for a standard 36-week school year, a 44.86% annual savings is observed or $820,800,000 USD by replacing that serving with beans.

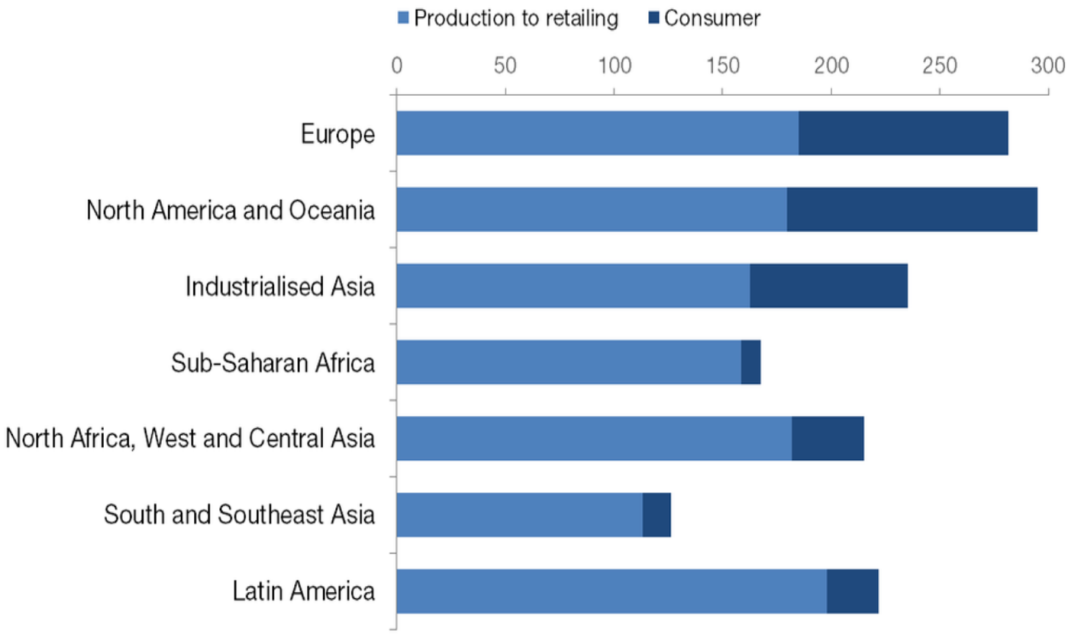

Figure 3. Global Food Losses and Food Waste Per Capita, kg/year (FAO, 2023)

There are additional economic benefits of replacing beef with beans in lunches, some of which include:

1. Beans are generally less expensive than beef, which can help schools, restaurants, and other food service providers to reduce costs and potentially lower prices for consumers (USDA, 2023; Drewnowski, 2010).
2. Plant-based diets, including those that incorporate beans instead of beef, have been shown to have health benefits that could potentially reduce healthcare costs over time (Clem & Barthel, 2021; WHO, 2015). If we consume less meat, we could potentially save over $735 billion/year in health-related costs globally (Rust et al., 2020).
3. Beans have a smaller environmental footprint than beef, with less land and water use, lower greenhouse gas emissions, and reduced deforestation. This could potentially lead to cost savings for communities and society, although these benefits are more long-term (Heller et al., 2020).

LIMITATIONS

While this method of carbon accounting as a justification for mitigating climate change could be deemed as short-sighted, CO2 is a molecule of major concern (IPCC, 2023). Future work should focus on LCAs of all GHG emissions and include a full analysis of cradle to grave for both bean and beef. This work considered reviews of LCAs which inherently carry their own biases and can be challenging to compare heterogeneously.

There are also broader limitations concerning health and culture. The necessary grams of protein per kilogram for the school age population is still debated, even amongst the medical community, and as the amount of protein per meal increases or decreases so will the corresponding impact on carbon emissions (Hudson et al., 2021). Additionally, future work

should expand on the cultural implications of replacing beef with beans in K-12 schools. This can impact school districts with greater Indigenous populations, populations that value beef as more than a means of satiation, and students who grew up in a meat-heavy household and may have difficulty adjusting their palates to a plant-based diet.

CONCLUSION

Overall, replacing beef with beans in school lunches can provide numerous benefits, including improved student health, increased animal welfare, and reduced environmental impact. By making this simple change, schools can promote sustainable and healthy eating habits, educating students about the importance of reducing their environmental footprint while also providing them with a nutritious and satisfying meal. The benefits of this change are significant, and it is an important step towards a more sustainable and healthy future. From an economic perspective, the replacement of beef with beans in school lunches, assuming beef is served every other meal, would result in a $1.67 billion annual savings from the carbon dioxide not emitted into the atmosphere.

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