TOWN OF
CARRBORO

TRANSMITTAL **Planning Department**

DELIVERED VIA: ☐ *HAND* ☐ *MAIL* ☐ *FAX* ☒ *EMAIL*

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Date: **February 8, 2022**

Subject: **Town of Carrboro Dietary Greenhouse Gas (GHG) Emissions Inventory**

Summary

The Town of Carrboro's Community Climate Action Plan (CCAP), accepted in 2017, contains recommendations on food choice measures. One of the plan's food choice recommendations involves developing a method to capture diet-related greenhouse gas (GHG) emissions and measure progress towards the Town's reduction goal. In 2019, Town staff worked with BKL Research & Consulting to develop a survey to obtain data related to the composting, gardening, food choices, and commuting habits of Carrboro residents.

Using the survey's annual self-reported meat and dairy consumption among Carrboro residents, the Town's Environmental Sustainability Coordinator worked with Doctoral Candidate and Climate Action Team (CAT) member Chrissie Schalkoff to perform an analysis of associated greenhouse gasemissions.

Overall, annual meat and dairy consumption contributed an estimated 17,484 metric tons CO_2-equivalent (CO_2-eq) to Town GHG emissions. Beef consumption contributed the greatest amount to total meat and dairy emissions, despite consumption in an average of only 2.7 meals/week for residents.

In addition to this dietary emissions inventory, the Town has completed several community GHG emissions inventories. The geographic boundaries for the dietary inventory are different than the community inventories, as except for indirect emissions from electricity generation, the geographic scope of the community inventories lies within the Carrboro city limits. Emissions from this dietary inventory are created outside Carrboro city limits. These emissions would also be accounted for in inventories performed by other jurisdictions or at a larger, global level.

Several additional aspects of dietary emissions Carrboro are accounted for in the community GHG emissionsinventory. For example, electricity usage related to food storage in commercial and residential settings, as well as transportation by residents to purchase and consume food. More information about the system boundaries can be found in Figure 1.

It should also be noted that the dietary emissions inventory also accounts for food eaten by Carrboro residents outside of Carrboro city limits, as the survey did not make that distinction when asking residents about weekly food consumption.

CCAP Food Choice Recommendations

The CCAP states that monitoring progress towards diet-related greenhouse gas emissions relies on understanding consumption patterns that occur outside of Carrboro in the development and creation of food as well as consumption occurring within the Town limits. Previous community-scale greenhouse gas inventories have focused on directly accountable activities, such as motor vehicle fuel consumption and metered utilities that occur within the Town limits. These emissions account for a percentage of the direct and indirect life-cycle emissions associated with the behaviors and activities of community members.

In relation to food, emissions for local transport, storage, and processing, cooking, and waste management are included within total estimates for transportation, electricity, natural gas, and waste. Town staff developed the 2019 CCAP survey to obtain data to create the baseline estimate of dietary emissions associated with the additional aspects of food production and consumption. The survey obtained data on the consumption of foods with the highest carbon footprint, meat and dairy products (2). Staff plan to re-administer the survey on a biennial basis. This will allow for benchmarking as the Town continues to implement additional food choice initiatives recommendation in the CCAP.

Establishing a broader baseline of food consumption emissions will raise awareness and support individual and household choices to shift from more carbon-intensive to less carbon-intensive diets.

Analysis Overview

The goal of this analysis was to estimate the annual GHG emissions associated with meat and dairy consumption in the Town of Carrboro. The analysis was modeled heavily on a 2019/2020 analysis of the Pittsburgh Urban Food System which was conducted by students at Carnegie Mellon University (2).

In order to capture GHG emissions associated with food consumption for a town, city, or region, it is necessary to know both 1) the average/estimated GHG emissions associated with production and processing of distinct food types (usually reported in kg CO2-eq/kg food); and 2) the annual estimated amount of each food type consumed in the area, in kg or metric tons.

Some analyses of GHG emissions from food consumption also include estimates of emissions from consumer transportation to purchase food, consumer or retail storage of food, and food waste disposal. For the purposes of this preliminary analysis of meat and dairy GHG emissions from dietary habits in the Town of Carrboro, this summary does not include transportation, consumer storage, or consumer food waste. Furthermore, additional limitations of this analysis are included in the *Limitations and Future Directions* section below.

Data Sources and Guiding Reports

Analysis Framework

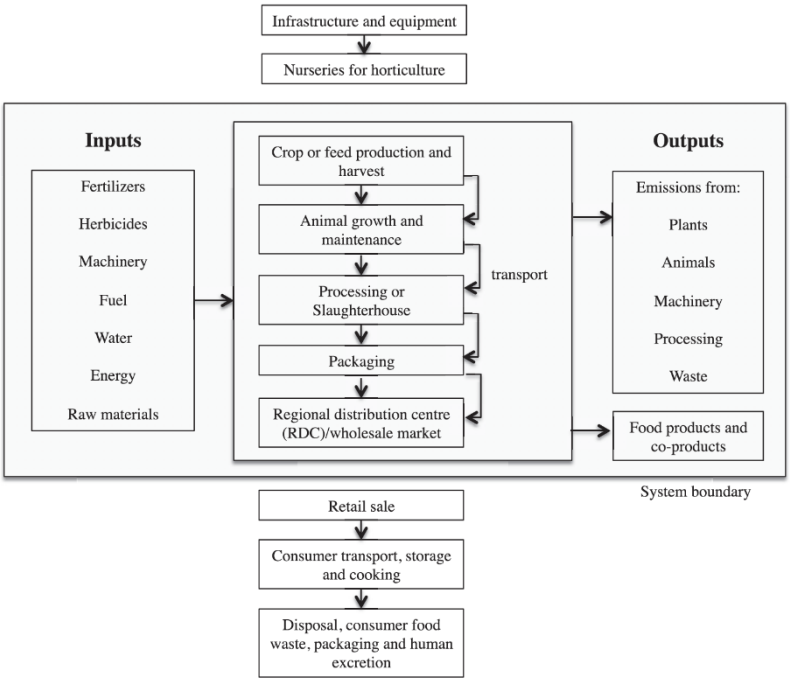
In January 2020, a group of students in the Department of Engineering and Public Policy and the Department of Social and Decision Sciences at Carnegie Mellon University conducted a comprehensive inventory of GHG emissions associated with food consumption in Allegheny County, PA. This inventory accounted for emissions associated with food production, transportation into the county, distribution to retail outlets, storage, and waste (2). This framework was used as a guide for the analysis. Due to differences and limitations in available data sources at the Town level for just the Town of Carrboro, the

inventory did not include all of the elements of the Pittsburgh Urban Food System report; however, emissions associated with food production and transportation to retail centers were analyzed in the same way as in the report.

GHG Emission Factors

GHG emission factor estimates were obtained from Clune et al.'s 2017 systematic review of food category greenhouse gas emissions (3). This systematic review and meta-analysis included worldwide data from the last 15 years (at the time of publication) and compiled manuscripts published in peer-reviewed journals, conference proceedings, and Environmental Product Declarations that included life cycle assessment (LCA) studies (3). In order to compare estimates across studies and geographic locations and compute basic descriptive statistics, the authors converted emissions factor values into a common functional unit of kg CO2 equivalent/kg bone free meat (BFM) or produce. Furthermore, different LCA studies used different "system boundaries," i.e., the portion of the entire food production pathway included in the emissions calculation (e.g., farm to slaughterhouse vs. farm to regional distribution center vs. farm to cooked in home). Therefore, study authors also converted all emissions factors to fit the farm to regional distribution center (RDC) boundary (3). **Figure 1** (from Clune et al.) indicates the part of the entire food life cycle (shown within the box) that was included in this systematic review and meta-analysis (3).

Figure 1. From Clune et al. (2017). Simplified system boundary.



Due to the system boundary used, emissions factor estimates compiled in the review represent energy expended from 1) farm activities, including chemical/fertilizer use, irrigation/machinery, harvesting/processing, and emissions from soils, plants, and animals in fields; and 2) transport and refrigeration from farm to RDC (2).

Estimates were compiled and organized by food type, and median, mean, minimum, and maximum emissions factor estimates were provided across all studies and by continent/world region when available (2).

Carrboro Food Type Quantities

Estimates of food types and quantities consumed by Carrboro residents annually were obtained from the results of the 2019 Town of Carrboro Community Climate Action Plan Survey. This survey was conducted from November 25th through January 16th, 2019 by BKL Research & Consulting and was administered by phone to a sample of 401 Carrboro residents using standard random sampling survey methods. Both listed/unlisted landline and wireless telephone numbers coinciding with census tracts in the Carrboro area were included in the sampling frame. Participants included residents of Carrboro who were over the age of 18. Food questions included on the survey asked about weekly consumption of dairy, meat, and beef (reported in number of meals/week consumed), as well as self-reported identification of dietary preference lifestyles such as vegetarianism, pescatarianism, veganism, and dairy-free eating. A copy of the food items asked in the survey is included in **Appendix A.**

National Dietary Habit/Meal Reference Amount Food Values

Estimates of the quantity of different food types typically consumed by Americans during meals were obtained from United States Department of Agriculture (USDA) serving size dietary guidelines (3) and a 2018 Food and Drug Administration (FDA) report of Reference Amounts Customarily Consumed (4).

Methods/Analysis Steps

Following the same method employed in the Carnegie Mellon University "Climate Change and the Pittsburgh Urban Food System" report (2020), the final GHG footprint of dairy, meat, and fish consumption in Carrboro was calculated by multiplying quantities of food consumed by their respective GHG emissions factors (2), after converting food quantities to the requisite compatible metric.

Emissions factor estimates were obtained from Clune et al.'s 2017 systematic review and meta-analysis (3). Mean estimates for the products included in the Carrboro Community Climate Action Plan survey are shown in **Figures 2 and 3**. Overall (global) and North America (NA - when available) mean, median, minimum, and maximum emissions factor estimates were used, to produce a range of final estimates.

Figure 2. Emissions factor estimates (Clune et al., 2017).

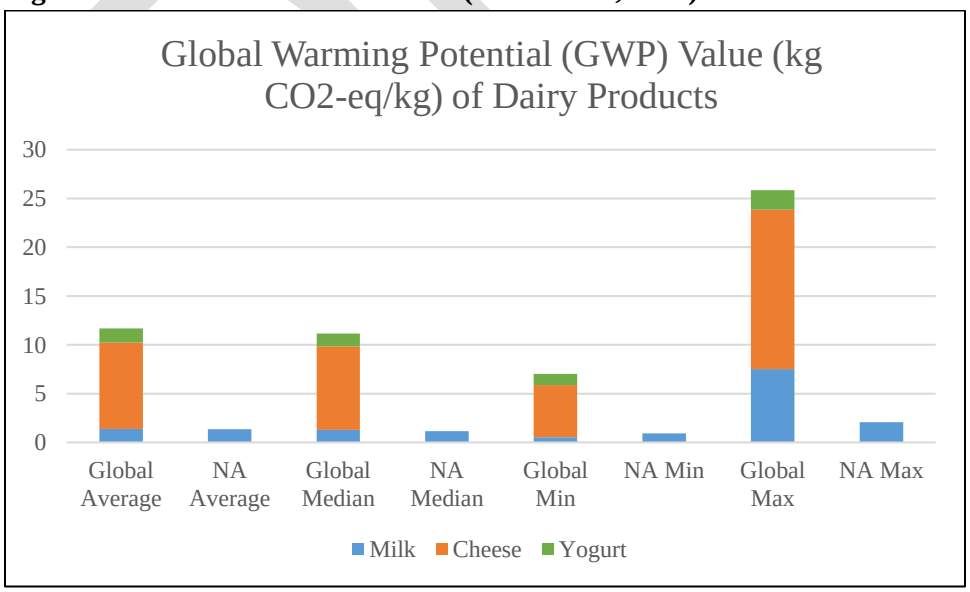
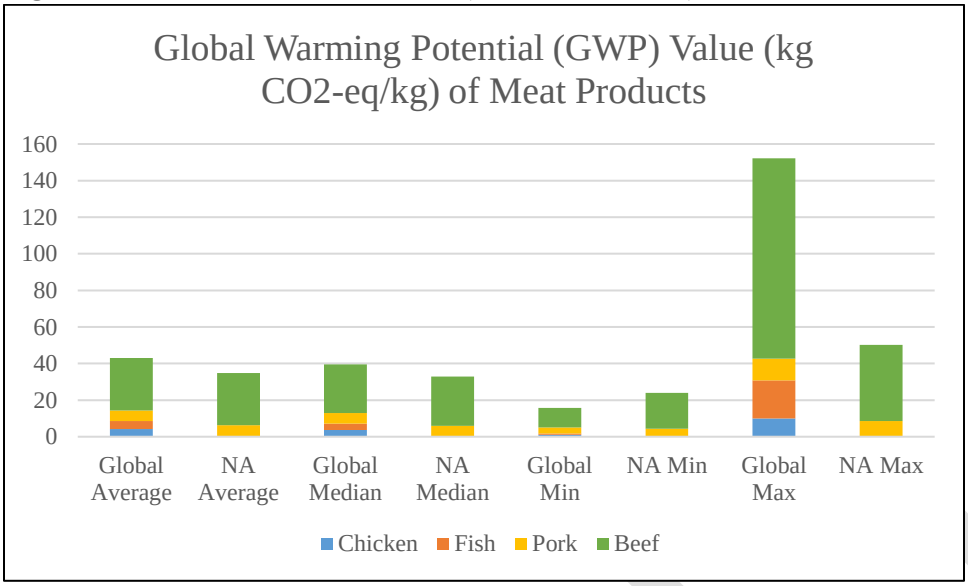


Figure 3. Emissions factor estimates (Clune et al., 2017).



Food quantity estimates for the Town of Carrboro were obtained from the Carrboro Community Climate Action Plan Survey. As participants were asked about the average number of meals per week that they consumed that included a particular food category, additional steps were needed to convert the survey data into food quantities by weight. To do this, it was necessary to obtain an idea of the approximate average portion size of each type of food, in order to calculate an estimate of how many grams/kg of food were consumed at each meal. Estimates of typical amounts of food consumed in a meal were obtained by referencing the USDA's serving size guidelines and the FDA's Reference Amounts Customarily Consumed report (3,4).

Following this, GHG emissions were then able to be calculated both per capita for Carrboro residents annually and for the Town overall, given the random sampling employed by the Community Climate Action Plan survey. To obtain overall Town GHG emission estimates, the per capita average calculated was then multiplied by the Town of Carrboro population as reported by the U.S. Census Bureau (5).

Figure 4. GHG Emissions Calculation Process.

Step 1: average *# meals/week containing food product x average portion size (kg)/meal = kg food product/week*

Step 2: *kg/week x 52 weeks/1 year = kg food product consumed/year (average, 1 person)*

Step 3: *kg food product x product emissions factor (kg CO2-eq/kg) = kg CO2-eq annually (1 person)*

Step 4: *individual kg CO2-eq x Town of Carrboro population estimate = kg CO2-eq annually (Town)*

Step 5: *kg CO2-eq x 1/1000 = **metric tons CO2-eq annually (Town)***

Note: The survey was only administered to residents over age 18. The assumption was made that residents under age 18 follow similar eating habits to residents over age 18 with which they reside. The U.S. Census Bureau states that 20.9% of Carrboro residents are below the age of 18 (7).

Preliminary Results

Basic participant demographics and self-reported dietary habit information collected in the Carrboro Community Climate Action Plan Survey are reported in **Table 2**. Overall, approximately half of the sample consisted of adults between the ages of 36 and 55, and the sample was split fairly evenly between men and women (self-reported gender identity). Approximately 80% of the sample consisted of white/Caucasian individuals, 7% of participants were Black/African American, and 6% reported Hispanic ethnicity. The demographics of the survey sample differ slightly from the actual demographics of the Town, which can be obtained from the U.S. Census Bureau. Additionally, 6.6% of respondents reported following a vegetarian diet, which is higher than the national average of 5% (6). The percentage of residents in Carrboro who follow a vegan diet is consistent with the national average of 3% (Hrynowski, 2019).

Table 2. Demographic and dietary characteristics of survey sample.

Characteristic	All participants (n = 401)
Age (years)	
18-25	9.7%
26-35	19.2%
36-45	23.6%
46-55	26.7%
56-65	12.6%
66-75	4.9%
>75	3.3%
Male (%)	51.5%
Female (%)	48.5%
Race/Ethnicity	
Caucasian	79.1%
African American	6.9%
Hispanic	5.8%
Native American	0.3%
Other	5.0%

Table 2 (Continued). Demographic and dietary characteristics of survey sample.

Average # of Meals/Week Containing Dairy	12.1
Average # of Meals/Week Containing Meat	9.5
Average # of Meals/Week Containing Beef (of those containing meat)	2.7
Vegetarian Diet	6.6%
Vegan Diet	2.8%
Pescatarian Diet	3.8%
Dairy-Free Diet	4.6%

Estimated annual GHG emissions associated with Town of Carrboro residents' self-reported consumption of meat and dairy products are shown in **Table 3**. As participants were only asked about "dairy products" and "meat" in general (with the exception of beef), estimates were produced by obtaining emissions factor estimates for the most common types of dairy products and meat available, calculating annual emissions associated with each product, and averaging across products. When available, North America average emission factor estimates were used (2); if not available, the general Clune et al. reported average was used.

A full range of estimates for each included food category, using each of the Clune et al. emissions factor estimates reported (North America and global mean, median, minimum, and maximum emissions factor estimates) can be found in the attached spreadsheet.

Table 3. Dairy and Meat greenhouse gas emission estimates for the Town of Carrboro, 2019.

Food category	Town GHG annual emissions estimate (tons CO_2-eq)	Per capita GHG annual emissions estimate (tons CO_2-eq)
Dairy products (average milk/cheese/yogurt; 12.1 meals/week)	4,083 metric tons	0.193 metric tons/person
Non-beef meat (average chicken/pork/fish; 6.8 meals/week)	4,058 metric tons	0.192 metric tons/person
Chicken	3,396 metric tons	
Pork	5,143 metric tons	
Fish	3,635 metric tons	
Beef (2.7 meals/week)	9,343 metric tons	0.441 metric tons/person
Overall dairy + all meat average*	17,484 metric tons	

Note: Calculations assumed 12.1 meals per week containing dairy, 6.8 meals per week of non-beef meat, and 2.7 meals per week with beef.

The overall estimated GHG emissions produced by average annual dairy and meat consumption of Town of Carrboro residents was calculated to be 17,484 metric tons CO_2-eq. For comparison, according to the most recent Town of Carrboro GHG Emission Inventory, in 2012 the Town produced 111,954 tons CO_2-eq (7); residential energy contributed 43,406 metric tons, and transportation accounted for 31,183 metric tons. Dairy and meat consumption alone among Carrboro residents therefore contributed as much toward Town emissions as more than 50% of all Carrboro transportation (at 2012 levels) (7).

Reducing Individual Dietary GHG Emissions Footprints

Staff plan to utilize the data and results from this research to develop methods for meeting the CCAP goal of an 80% reduction in dietary GHG emissions by 2030.

Reducing Emissions by Consuming Organic Foods

The Pittsburgh Urban Food System report examined research on the greenhouse gas emissions produced by choosing organic food (2). **Table 4** summarizes data from Tables 3.1 and 3.2 in the Pittsburgh Urban Food System report. Consuming organic fruits and vegetables results in the highest greenhouse gas emissions reduction per food category while consuming organic dairy and poultry resulted in increased greenhouse gas emissions.

The authors noted that the number of studies on emissions from organic food is limited (2). Further research should be performed to determine more conclusive data about the impact of choosing organic foods on greenhouse gas emissions.

Table 4. Summary of Tables 3.1 and 3.2 from the Pittsburgh Urban Food System Report (2), including percent change in emissions by consuming organic food in each category.

Food Category	Mean Emissions (CO2-eq/kg) for Non-Organic Foods	Mean Emissions (CO2-eq/kg) for Organic Foods	% Change in Emissions by Consuming Organic
Dairy	7.6	12	58%
Milk & Cream	1.4	1.4	0%
Fruit	0.7	0.3	-57%
Vegetables	0.9	0.2	-78%
Beef	28.7	25	-13%
Pork	5.8	5.1	-12%
Lamb	27.9	11	-61%
Poultry	4.1	5.7	39%
Eggs	3.3	4	21%
Oils/Fats/Nuts	1	2.3	130%
Cereals/Grains	1	1.7	70%
Legumes	0.8	0.4	-50%
Fish	4.5	3.2	-29%
Shellfish	13.1	13	-1%

Additional Ways to Reduce Dietary GHG Emissions Footprints

Staff utilized the Pittsburgh Urban Food System report (2) to estimate ways in which Carrboro residents can reduce their dietary GHG emissions footprints without changing the specific foods they consume. In addition to embodied emissions in food production, dietary GHG emissions footprints consist of food transportation, storage, and food waste related to the home, retail, and food service sectors. If a Carrboro resident walked or biked to purchase their food, purchased food from local producers, and composted their food waste, they could reduce their dietary emissions footprint by approximately 15%. The overall emissions breakdown in the Pittsburgh Urban Food System report is provided below in **Figure 5**.

Figure 5. Total Greenhouse Gas Emissions for the Allegheny County Food System

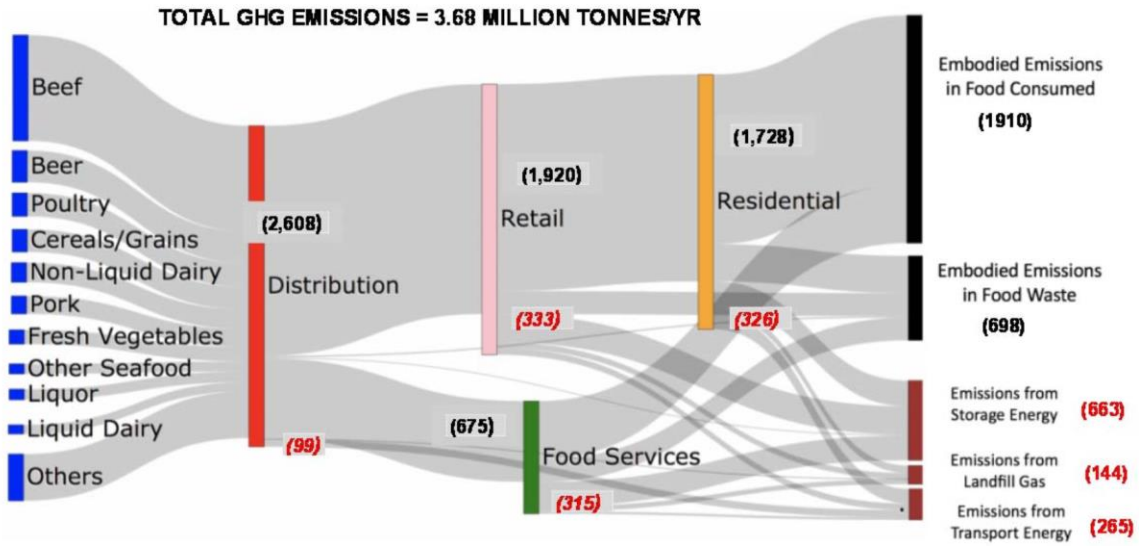


Figure ES-1: Greenhouse Gas Emissions for the Allegheny County Food System. All values are in 1,000 tonnes CO_2-eq/ yr). Numbers in black are embodied emissions from food production and packaging; values in red are total additional emissions from landfills and energy used for food transport and storage.

In addition to future work to capture more of the food life cycle and associated emissions in the Town of Carrboro, initial educational materials can be produced to help disseminate results to community members. Sample educational pamphlets are shown in **Figures 6 and 7** below.

Figure 6. Sample educational materials

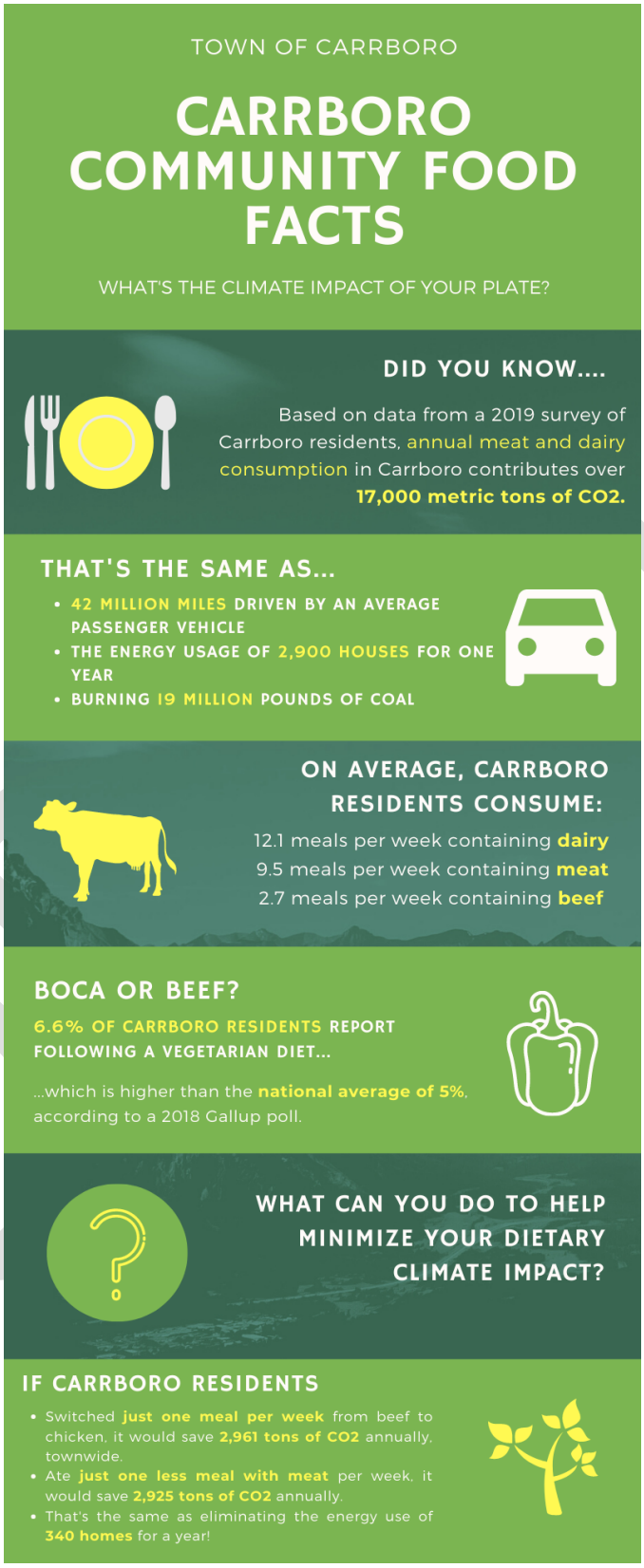
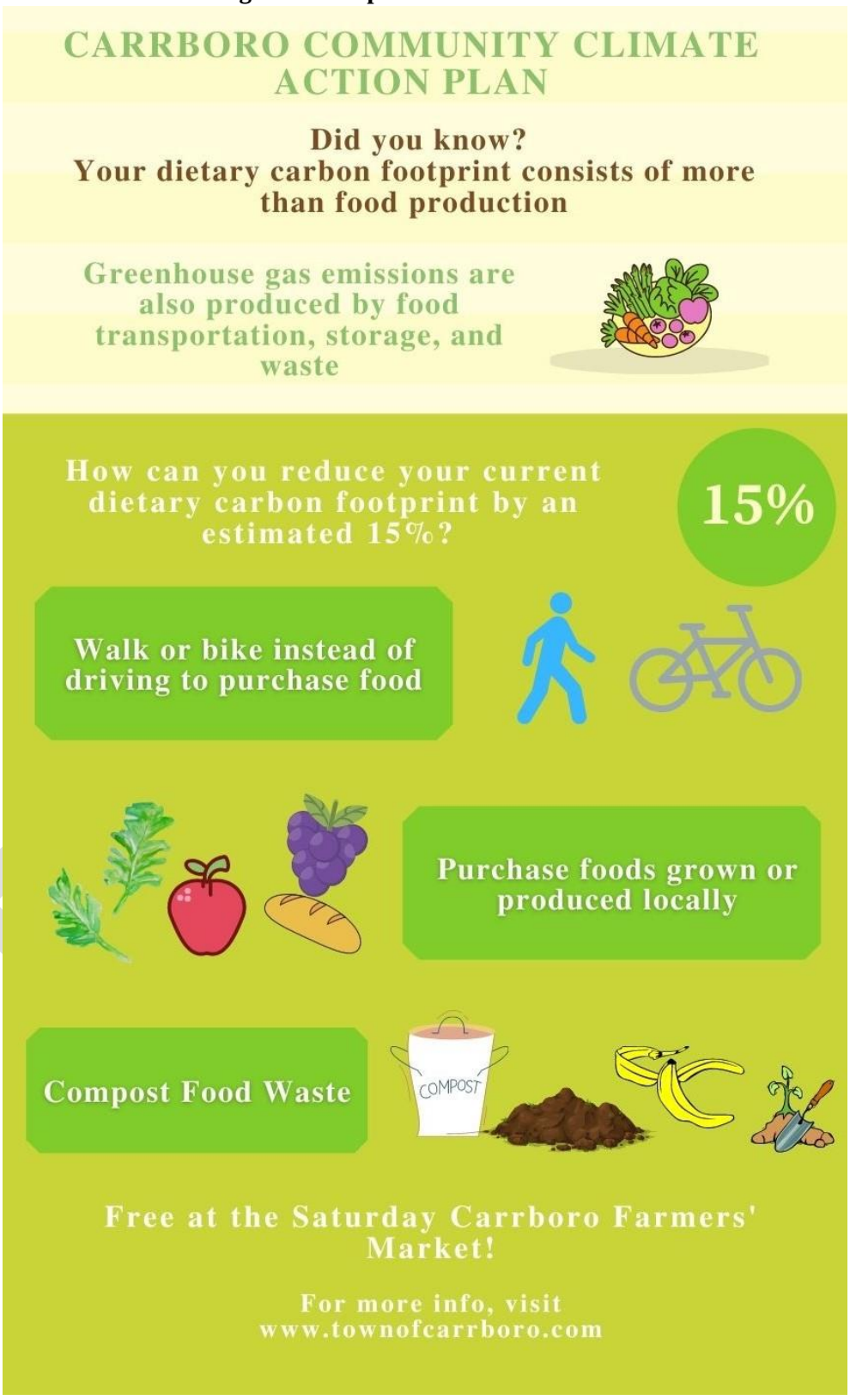


Figure 7. Sample educational material.



Limitations and Future Direction

It is important to note that this preliminary analysis has several key limitations that should be considered when interpreting results.

First, survey respondents only indicated the approximate/average number of meals per week that included dairy or meat products; the survey did not capture exactly which type of dairy products were consumed nor the breakdown of how many of each type of meat products per week were included. This meant that multiple assumptions had to be made about portion size and exact food product type, leading to a range of possible estimates. It was assumed that Carrboro residents adhere to the portion sizes stated in the USDA's serving size guidelines and the FDA's Reference Amounts Customarily Consumed Report. Additionally, the accuracy of participant recall when asked to estimate how many meals in a week included a certain food product may be less than desired; in future surveys, measures such as a 24-hour dietary recall (such as those used by the National Health and Nutrition Examination Survey) could be considered (8).

Furthermore, based on the data captured by the Carrboro Community Climate Action Plan Survey and emissions factor estimates from Clune et al.'s meta-analysis, only dietary emissions associated with part of the life cycle of dairy and meat products consumed – this analysis did not include emissions associated with consumer transportation to obtain food, food storage, or food waste. As such, results from this analysis are likely underestimating total food-related emissions. Future analyses could include these parts of the food life cycle.

Finally, the survey did include a random sample of 401 residents; random sampling allows for more representative/generalizable conclusions about Town of Carrboro habits and behavior. However, the sample captured was not entirely demographically proportionate to the Town as a whole. In addition, the survey was only administered to residents over age 18. The assumption was made that residents under age 18 follow similar eating habits to residents over age 18 with which they reside. This preliminary analysis is a starting point and in the future, estimates may need to be weighted and adjusted to account for some of the assumptions made in this analysis

References

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Appendix A

Dietary Items from Carrboro Community Climate Action Plan 2019 Survey

We now have a few questions regarding dietary choices

11. Out of an average of 21 meals per week (3 daily), how many of these meals on average contain dairy products?

    _____

12. Out of an average of 21 meals per week, how many of your meals on average contain meat (beef, pork, chicken, fish)?

    _____ (If zero, skip to #14)

13. Out of those (#12 response), how many of these meals on average contain beef?

    _____

14. Do you follow a vegan diet?

    ❑ Yes (Skip to #20) ❑ No (Continue)

15. Do you follow a vegetarian diet?

    ❑ Yes (Skip to #19) ❑ No (Continue)

16. Do you follow a pescatarian diet?

    ❑ Yes (Skip to #19) ❑ No (Continue)

17. Have you considered eating fewer meals with meat/meat products?

    ❑ Yes (Continue)
    ❑ No What would be an incentive for you to do so? (Ask and skip to #19)

    _____

18. What do you find is the most challenging aspect about eating fewer meals with meat?

    _____

19. Do you follow a dairy-free diet?

    ❑ Yes ❑ No

20. What percentage of the food you eat was produced locally? (If zero, skip to #22)

    _____

21. What types of food do you eat that are produced locally? (Read choices)

    ❑ Produce ❑ Meat ❑ Dairy ❑ Baked Goods ❑ Other _____

22. What percentage of the food you eat is organic? (If zero, skip to #24)

    _____

23. What types of food do you buy organic? (Read choices)

    ❑ Produce ❑ Meat ❑ Dairy ❑ Baked Goods ❑ Other _____

24. What most influences your daily food choices?

    _____

Appendix B

Data from United States Department of Agriculture (USDA) serving size dietary guidelines and 2018 Food and Drug Administration (FDA) report of Reference Amounts Customarily Consumed

Food Type	Ave Portion Size/Meal (g for meat, mL for liquids)	Ave Portion Size/Meal (kg/meal)
Milk	240	0.24
Cheese	55	0.055
Butter	15	0.015
Yogurt	170	0.17
Chicken	110	0.11
Fish	110	0.11
Pork	110	0.11
Beef	110	0.11