UBC-O CAP FOOD BASELINE PROJECT REPORT

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Territorial Acknowledgement

We respectfully acknowledge that the activities highlighted in this report take place on the unceded, stolen territory of the Syilx Okanagan Nation. As this institution evaluates our contribution to climate change through food related waste and emissions, we must be explicit about the many ways in which Indigenous food systems and food sovereignty continue to be disrupted by historic and ongoing colonization. No food system can be considered just or sustainable until Indigenous food sovereignty is acknowledged, restored, and reconciled.

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Executive Summary

This project was sponsored and facilitated through the UBC Okanagan (UBC-O) Campus Planning Sustainability Office, with research support from Dr. Nathan Pelletier, to inform the UBC Okanagan Climate Action Plan 2030 (UBCO CAP 2030). This report aimed to develop baseline inventories of both food offerings and food waste on the Okanagan campus and to estimate associated greenhouse gas (GHG) emissions. The intention of this report is to address local operational needs and provide insight as to the significant and cost-effective opportunities available for mitigating food related GHG emissions on the UBC Okanagan campus.

The UBC-O Food Offering Inventory was developed using mass and cost data collected from Sunshine, Picnic, and Comma Food Service operations from July 2019 to June 2020. The food offering inventory was grouped into different food types and assigned emission factors derived from the database of Food Impacts on the Environment for Linking to Diets (dataFIELD). GHG emissions per kg and per dollar for each food category were estimated (Figure 1a). Beef products contributed 41% (654 tCO_2-eq) of the total GHG emissions associated with the food offering inventory, while only accounting for 2% of the inventory mass. Findings suggest food procured by UBC-O Food Services emitted an estimated 1,616 tCO_2-eq GHG emissions from July 2019 – June 2020, making it the fourth largest contributor to the UBC-O carbon footprint.

The UBC-O Food Waste Inventory was developed using waste and compost data collected from August 2019 to July 2020 and from a previously performed 2018 campus-wide waste audit. Avoidable and unavoidable food waste was estimated for six food categories: meat and poultry, dairy and eggs, marine, sugars and syrups, produce, and bakery. An estimated 47% of food waste was avoidable plate waste, accounting for 98.4 t of CO_2-eq GHG emissions.

Findings suggest that the most effective strategies for reducing food related GHG emissions are as follows:

(1) Reduce ruminant-derived products (particularly beef) available on campus and replace them with equivalent plant-based alternatives or other medium to low impact foods. Foods that are high in both emissions/$ and emissions/kg present cost-effective opportunities for targeted food related GHG emissions reductions. Plant-based meat alternatives emit 3% of the GHG emissions of beef per dollar and plant-based dairy products emit 25% of the GHG emissions of dairy products per dollar. Replacing 100% of ruminant-derived products with these alternatives therefore has the potential to be cost effective while reducing 717 tCO2-eq emissions per annum.

(2) Reduce avoidable plate food waste through lean menu design and portion control with a focus on commonly wasted foods that are also emissions intensive – like meat and ruminant-based products.

(3) Divert food waste from the landfill through expansion and monitoring of the underutilized campus composting program, which provides a post-consumer carbon offset. Transitioning 100% of food waste from the landfill to the compost program avoids 11.5 tCO2-eq emissions and increases the carbon offset from composting by 2.6 tCO2-eq emissions per annum.

Data limitations of this report can be resolved for future evaluations of food related operations on campus if (1) food waste data collection efforts are performed at a higher resolution and (2) upstream processes are incorporated through collaboration with suppliers.

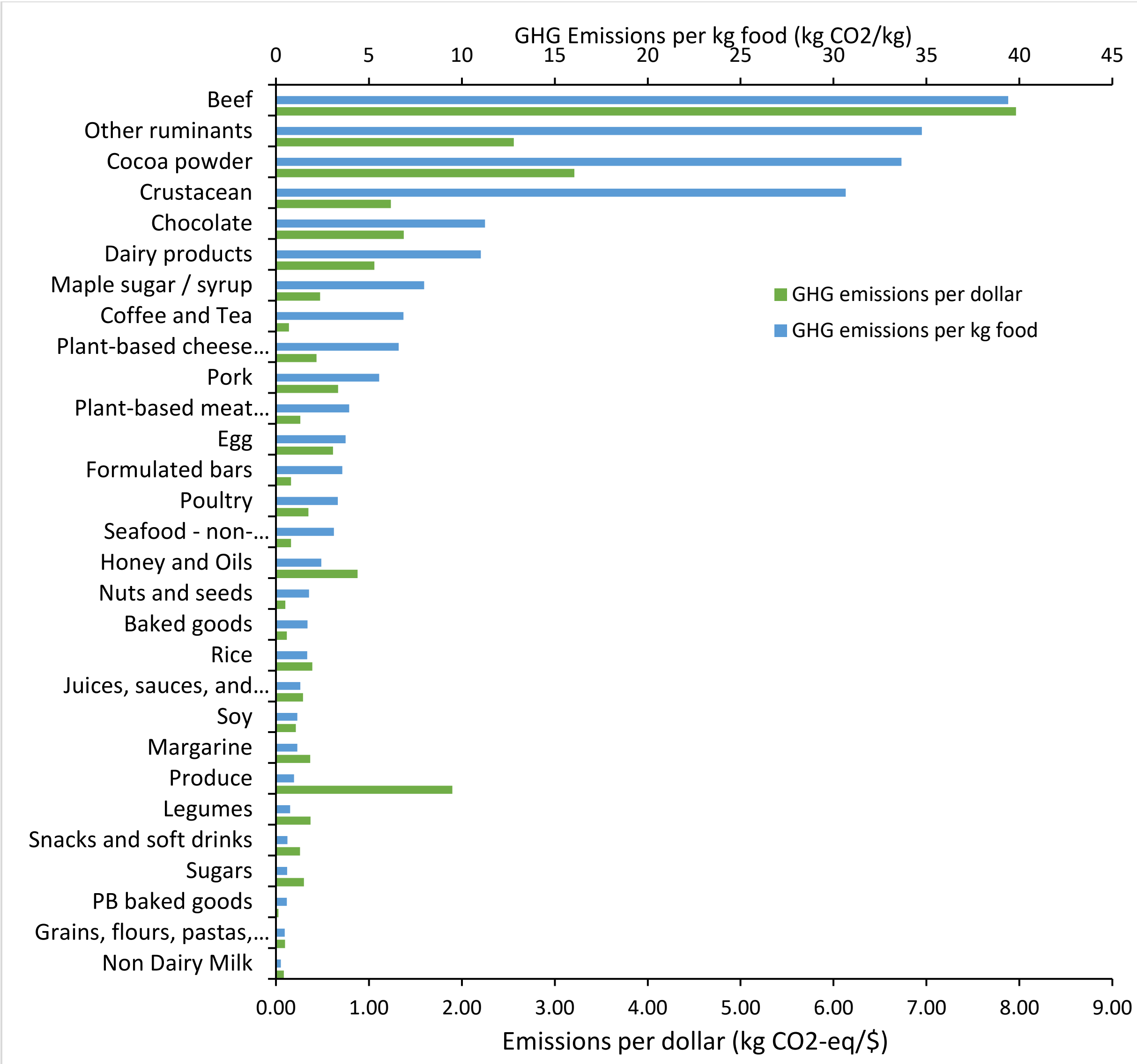

Figure 1a. Total GHG emissions of food items in the food offering inventory per dollar spent (kg CO2-eq/$; green) and per kg food item (blue). Foods that are high in both emissions/$ and emissions/kg present cost effective opportunities for targeted food related GHG emissions reductions. Note that emissions per dollar for produce is disproportionately higher than GHG emissions per kg due to its comparatively low cost per kg.

Introduction / Overview

In 2019, the University of British Columbia (UBC) declared a climate emergency to meet the urgent call to climate action by the Intergovernmental Panel on Climate Change (IPCC 2018). As part of these efforts, the development of UBC Climate Action Plans (CAP) on both the Okanagan and Vancouver campuses will provide a strategic path to climate change mitigation and identify opportunities within institutional sectors for targeted greenhouse gas (GHG) emission reductions. The food sector has received recent attention in the arena of climate action as it is responsible for one third of global GHG emissions (Crippa et al. 2021). Food loss and waste is a significant source of avoidable GHG emissions and has been declared a key pathway for reducing food-related emissions (Clark et al. 2020), as has preferential consumption of less GHG-intensive foods (Hoolohan et al. 2013). According to the avoidable crisis of food waste (ACFW) report performed by second harvest, 21% of avoidable food waste in Canada occurs at the consumer stage, where it is socially accepted to waste food (Gooch et al. 2019). As an institution that provides food services to over 13,000 faculty, staff, and students on the UBC Okanagan (UBC-O) campus, UBC-O can play a significant, evidence-based role as a societal influencer of what is normatively considered climate friendly food (Marshall and Anderson 2002).

The purpose of this report is to map the GHG emissions associated with the origins, consumption and disposal of food offered by the UBC-O campus food system and to identify priority areas for targeted greenhouse gas (GHG) emission reductions. The evaluation provided in this report will support recommendations and targets with respect to UBC-O's food offerings and waste strategies within the context of the UBC Okanagan Climate Action Plan 2030 (UBCO CAP 2030). Further, it will provide a baseline against which future reporting of the UBC-O campus food system GHG emission reduction efforts can be compared.

Methods:

This report first maps the percentage of different foods purchased for the Sunshine, Picnic, and Comma campus food providers, which is inclusive of all campus-run food operations. Franchises and food trucks on campus and food service providers operated by the UBC Student Union Okanagan (UBCSUO) were not included (Table 1). The specific origins of these food items and upstream processes based on current supply chains were not included due to data availability constraints but should be subject to future analysis.

Table 1. Description of different food service providers present on campus and those that are included in this report, based on the STARS reporting format (AASHE 2019).

Food service providers	Present?	Included?
Dining operations and catering services operated by the institution	Yes	Yes
Dining operations and catering services operated by a contractor	Yes	No
Student-run food/catering services (e.g., regional or global brands)	No	No
Convenience stores	Yes	No
Franchises	Yes	No
Vending services	Yes	No
Concessions	Yes	No

Purchasing inventory data from July 2019 to June 2020 was used to determine weights and volumes of different food items. Where inventory was reported in volume or quantity of individual items (ex. muffins, buns, etc.), the US Department of Agriculture (USDA) FoodData central database was used to convert inventory amounts to mass values (USDA 2019).

GHG emissions were estimated using emission factors from the University of Michigan's dataFIELD (database of Food Impacts on the Environment for Linking to Diets) for different food items. This dataset is derived from Heller et al.'s (2018) life cycle assessment for US diets, which includes emission factors for food loss rates as estimated by the USDA. This dataset was the most geographically representative and comprehensive data available and was considered suitable for the context of the

UBC-O campus food system because most food items found in the inventory were included in the dataset. The life cycle boundaries of this dataset included all upstream processes up until the farm-gate (cradle-to-gate) and do not include the packaging, distribution, retail, or consumer stages. Some items in the dataset require processing, such as flours and refined sugars, among others; in these cases, a cradle-to-processor gate boundary was used (for further details see Heller et al. 2018).

Food groupings were developed from the dataset to suit the context of the purchase inventory (Table 2). All food items listed in dataFIELD were grouped together based on this categorization scheme. An emission factor for each group was assigned by averaging the emission factors of each food item within the group. The second, third, and fourth quartiles from the average emission factors of the aggregated groups were used to further categorize the food groups into high, medium, and low impact categories.

For food items not found in dataFIELD, other literature on food related emissions was consulted. Absolute values for emission factors of food items were not compared across literature as varying methodological choices prevent such comparisons. However, the difference between emissions factors within a dataset for different food groups were considered robust. Therefore, publications that contained both the missing food item not found in dataFIELD and at least one reference food item listed in dataFIELD, were consulted. The ratio between the reference food item and the missing food item was used to determine which impact quartile the missing food item fell within. For example, dairy cheese was not listed in dataFIELD, but the reference item dairy milk was included. Since the global dataset from Poore and Nemecek (2018) included both dairy cheese and dairy milk, the difference between the two emission factors was used to determine the placement of dairy cheese within the categorization scheme, relative to the placement of the reference food item, dairy milk. Food items that were added to the grouping scheme in this way were assigned the average emission factor for the impact quartile in which they were placed (Table 2).

Purchase inventory spending data was used to determine the cost of each food grouping. The cost per kg of food item was multiplied by the food item's calculated emission factor to determine the GHG emission-weighted cost of each food grouping.

Table 2. Categorization scheme used to aggregate inventory data into food groupings within high, medium, and low impact quartiles. Emissions factors assigned to each grouping were calculated from dataFIELD (Heller et al. 2018) and other sources (see below).

Impact Categories and Food Groups	EF (kg CO2-eq/kg)
High Impact	
Beef	39.4
Other ruminants	34.7
Cocoa powder	33.6
Crustacean	30.7
Chocolate	11.3
Dairy products[1]	11.0
Medium Impact	
Maple sugar / syrup	8.0
Coffee and Tea	6.9
Plant-based cheese and spreads[2]	6.6
Pork	5.6
Plant-based meat alternatives[3]	3.9
Egg	3.8
Formulated bars[4]	3.6
Poultry	3.3
Seafood; non-crustacean	3.1
Low Impact	
Honey and Oils	2.4
Nuts and seeds	1.8
Baked goods[5]	1.7
Rice	1.7
Juices, sauces, and vinegars	1.3
Soy	1.2
Margarine	1.1
Produce	1.0
Legumes	0.8
Snacks and soft drinks[6]	0.6
Sugars	0.6
Plant-based baked goods[7]	0.6

Grains, flours, pastas, and bread	0.5
Non-dairy milks	0.3

[1]To represent dairy products like butter, cream, and condensed milk, this emission factor is based on the dry weight of milk solids. DataFIELD provides a weight conversion factor of 8.33 to convert liquid milk mass to milk solids (Heller et al. 2018). A weight conversion factor of 1.11 was derived from the emission factor for cow cheese (9.97) found in Heller et al. (2018) and was used to convert cow and goat cheese to milk solids.
[2]Average EF for medium impact category used; categorized based on Liao et al. (2020).
[3]EF for plant-based meat alternatives (pea based) calculated as 10% of EF for beef (Heller and Keoleian 2018).
[4]Limited GHG emissions estimates are available for formulated (protein/nutrition) bars. Medium and low impact category food groups are included in the ingredients; therefore, the average EF across the medium and low impact categories was used.
[5]EF calculated by multiplying EF of grains, flours, pastas and breads by a factor of 2.9, based on Hoolohan et al. (2013).
[6]Average EF for low impact category used for snacks (chips) (Hoolohan et al. 2013). EF for soft drinks was calculated at 13:87 sugar EF to water EF ratio, based on the same methods described in Hoolohan et al. (2013). An average EF was calculated from the snack and soft drink EFs.
[7]Bespoke calculation assuming 45% flour, 55% sugar, as described in Hoolohan et al. (2013).

UBC-O Food Waste Inventory

Food waste on the UBC-O campus was estimated from waste and composting streams. Monthly volumes of waste produced on campus and sent to Glenmore Landfill from August 2019 to July 2020 was provided by campus operations. The percentage of food and yard waste within the waste stream on campus was based on the percent composition of waste described in the UBC-O campus waste audit, performed by GreenStep in 2018 (Mackintosh 2018). Estimated monthly volumes of compost from August 2019 to July 2020 was provided by Spa Hills Compost and UBC-O campus operations. The percentage of food and yard waste (not including compostable packaging, food containers, napkins and other materials accepted in the program) of the total composted material was estimated based on the 2018 waste audit report performed by GreenStep (Mackintosh 2018). Food and yard waste could not be further partitioned due to insufficient data. However, in a 2013 organics waste audit performed for the UBC Vancouver campus, yard waste was 0% of the organic waste produced from two cafes, a library, a residence and a residence dining hall (Fraser 2013). Therefore, food and yard waste was treated as 100% food waste for subsequent calculations.

The food waste inventory was further partitioned into the six food categories described in the Avoidable Crisis of Food Waste (ACFW) technical report: produce, meat and poultry, bakery, dairy and eggs, marine, and sugars and syrups (Gooch et al. 2019). The ACFW report provided average Canadian hotel and institution prep and plate – the latter of which was considered edible – waste estimates as a percentage of food entering the institution (Table 3). Therefore, to estimate food wasted in each category, the UBC-O Food Offering Inventory was first aggregated into these six groups. The amount of food wasted in the food offering inventory for each category was then calculated using the percentages described in the ACFW report. The relative contribution of waste produced in each food category (from the food offering inventory) was then applied to the food waste inventory. In this way, the food waste inventory was able to be further partitioned into food groups, despite lacking measured values at this level of granularity.

Table 3. Prep and edible waste percentages of the total volume of food entering an average Canadian hotel or institution for six food waste categories (Gooch et al. 2019) and their associated emission factors (Heller et al. 2018).

Category[1]	**Prep waste (%)**[1]	**Edible waste (%)**[1]	**Emission Factor (kg CO2-eq/kg)**[2]
Produce	11	10	9.3
Meat and Poultry	17	14	17.4
Bakery	16	13	1.8
Dairy and Eggs	13	11	7.4
Sugar and Syrups	1	1	2.9
Marine	4	4	16.9

[1]From the Avoidable Crisis of Food Waste Canada Technical Report (Gooch et al. 2019). Prep and edible waste percentages are of the total volume of food entering the institution. Produce included fresh and processed fruits and vegetables, nuts, chocolate, fruit juices, coffee, and tea. Bakery was considered to contain field crops, legumes, vegetable oils, soymilk, cereals and baked goods. Sugars and syrups included soft drinks. For an exhaustive list of included crop inputs and consumer products see Gooch et al. (2019).
[2]Emission factors for each category were derived from the University of Michigan's dataFIELD and include the GHG emissions associated with the cradle-to-farm gate, or in some cases cradle-to-processor gate boundaries, and do not include post-consumer (landfill) emissions (Heller et al. 2018).

Upstream GHG emissions (up to but not including the consumer stage) were calculated using emission factors from the University of Michigan's dataFIELD (Heller et al. 2018). Food items in dataFIELD were grouped into the six ACFW food waste categories (Gooch et al. 2019), and their associated emission factors were averaged to arrive at upstream emission factors for each of the six food categories (Table 3).

The U.S. Environmental Protection Agency's (EPA) Waste Reduction Model (WARM) was used to calculate post-consumer GHG emissions occurring from food waste being either landfilled or composted (U.S. EPA 2020). The WARM tool allows you to input attributes of the landfill used in your institutions waste stream. Input details for the Glenmore landfill were gathered through personal communication with the landfill staff (pers. comm. Gordon 2021) and are described in Appendix A.

Many uncertainties were introduced to the UBC-O Food Waste Inventory due to the nature of the empirical data provided. For example, some data came from expert estimates in place of measured values. However, the UBC-O Food Offering Inventory contained considerably less manipulations to the empirical data and was considered to be more robust. Therefore, the methods described above to arrive at estimated waste volumes and associated GHG emissions were incorporated in this report using the food offering inventory only. Post-consumer emissions for waste volumes derived from the food offering inventory were calculated for three food waste pathway scenarios: (1) if 100% of the wasted food was sent to landfill; (2) if 100% of wasted food was composted, and (3) if the ratio of landfilled to composted waste was the same as was observed in the food waste inventory.

Results

UBC-O Food Offering Inventory:

A total of 782,000 kg of food costing a total of $1,186M and emitting an estimated 1,616 tCO_2-eq of GHG emissions was purchased for campus food operations from July 2019 to August 2020. Based on this analysis, food offered at the Sunshine, Picnic, and Comma food operations alone are approximately UBC-O's fourth highest source of GHG emissions, after commuting, air travel, and buildings and energy. Produce accounts for 83% of the food mass purchased for campus and accounts for approximately 40% of the GHG emissions (Figure 1b). The highest contributor to GHG emissions is beef, accounting for 41% of GHG emissions, despite contributing only 2% of the mass of the food inventory. The third and fourth largest contributors to the GHG emission from the campus food system are dairy products and poultry at 8% and 3%, respectively. Both dairy products and poultry make up less than 2% of the food inventory. The most environmentally and pocket friendly foods included plant-based baked items, non-dairy milk, grains, flours, pastas, and breads, as well as nuts and seeds.

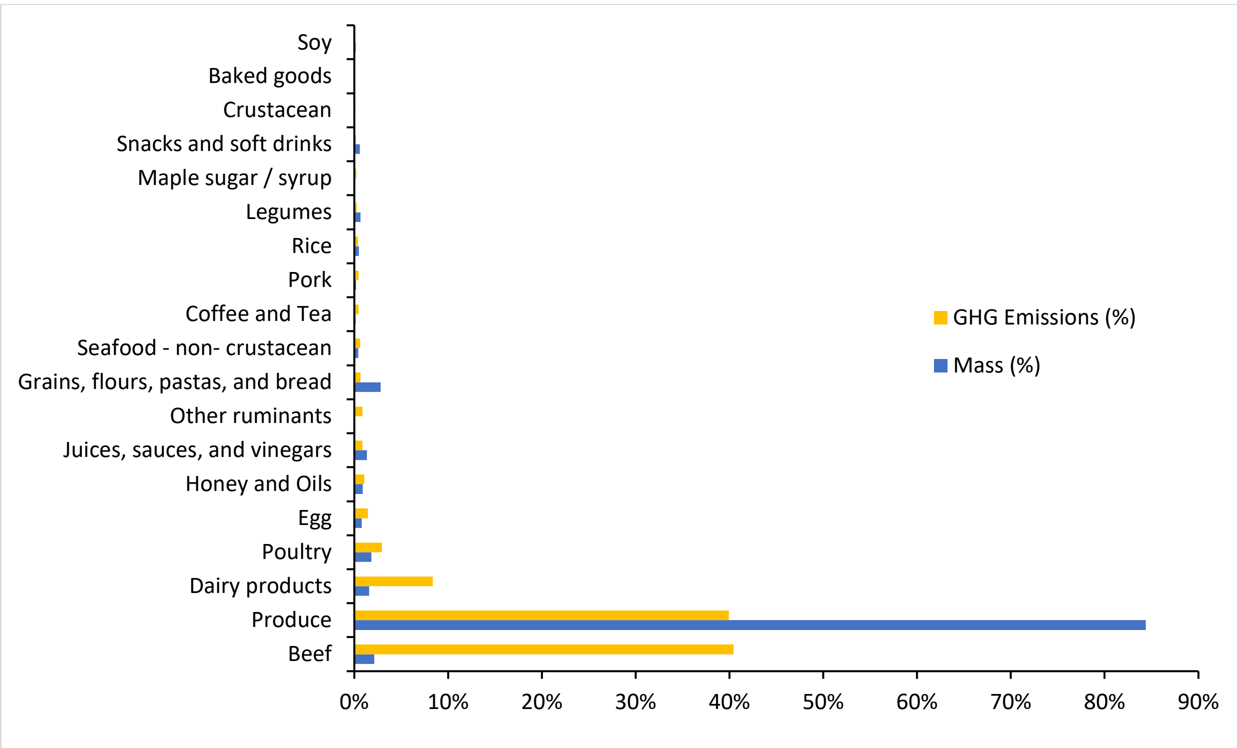

Figure 1b. Percentage of each food groups contribution to the total mass (blue) and estimated GHG emissions (yellow) of food items purchased for Picnic, Sunshine, and Comma operations. Food groups that contributed <1% to the total mass and estimated GHG emissions were not displayed.

Figure 2 shows the GHG emissions per dollar spent on food items in the UBC-O Food Offerings Inventory. Beef (8.0 kg CO2-eq/$) had the highest GHG emissions per dollar spent compared to other groups, followed by cocoa powder (3.2 kg CO2-eq/$) and non-beef ruminants (2.6 kg CO2-eq/$). The four food groups with the lowest emissions per dollar included plant-based baked items (3.3 e-02 kg CO2-eq/$), non-dairy milk kg CO2-eq/$), grains flours, pastas, and breads, (0.1 kg CO2-eq/$), and nuts and seeds (0.1 kg CO2-eq/$). Note that GHG emissions per dollar are disproportionately high for produced due to the comparably low expense per kg of food. A complete list of all food categories, their mass and associated GHG emissions per dollar and for each food provider is detailed in Appendix B.

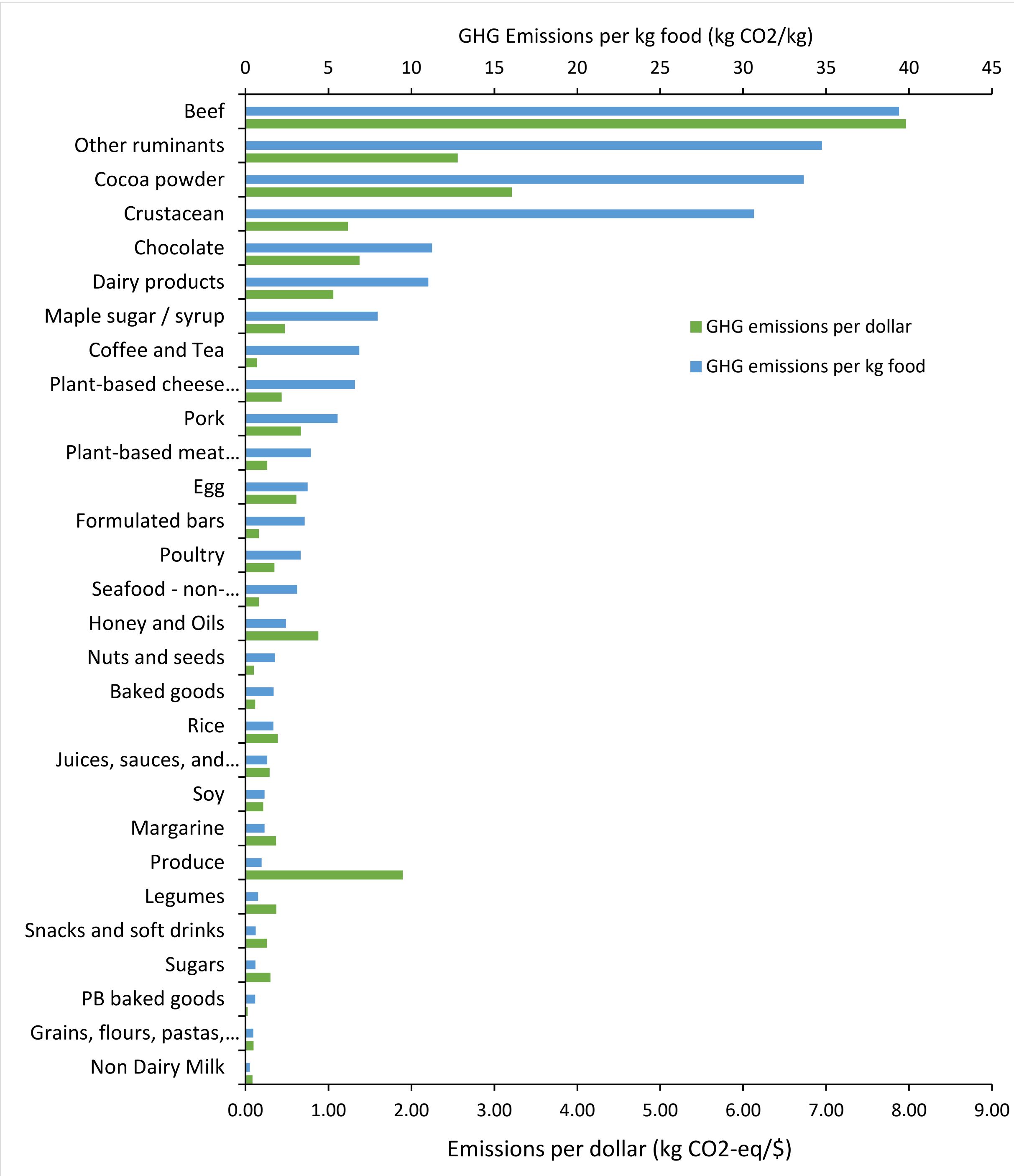

Figure 2. Total GHG emissions of food items in the food offering inventory per dollar spent (kg CO2-eq/$; green) and per kg food item (blue).

UBC-O Food Waste Inventory:

The annual volume of food (and yard) waste sent to landfill (August 2019 – July 2020) was estimated to be 18,030 kg (3% of total campus waste – excluding construction site waste). This is a relatively low estimated proportion of total campus waste compared to other academic institutions in British Columbia (Rajan et al. 2018; University of Victoria 2021). An estimated 3,540 kg of food waste was composted (7% of compostable materials). Of the total food waste sent to both landfill and compost facilities, 10,100 kg (47%) was estimated to be edible, accounting for 93.2 tCO2-eq of upstream life cycle GHG emissions (not including the post-consumer stage). Figure 3 describes the edible and prep waste and associated upstream GHG emissions for composted and landfilled waste, and across ACFWC food categories.

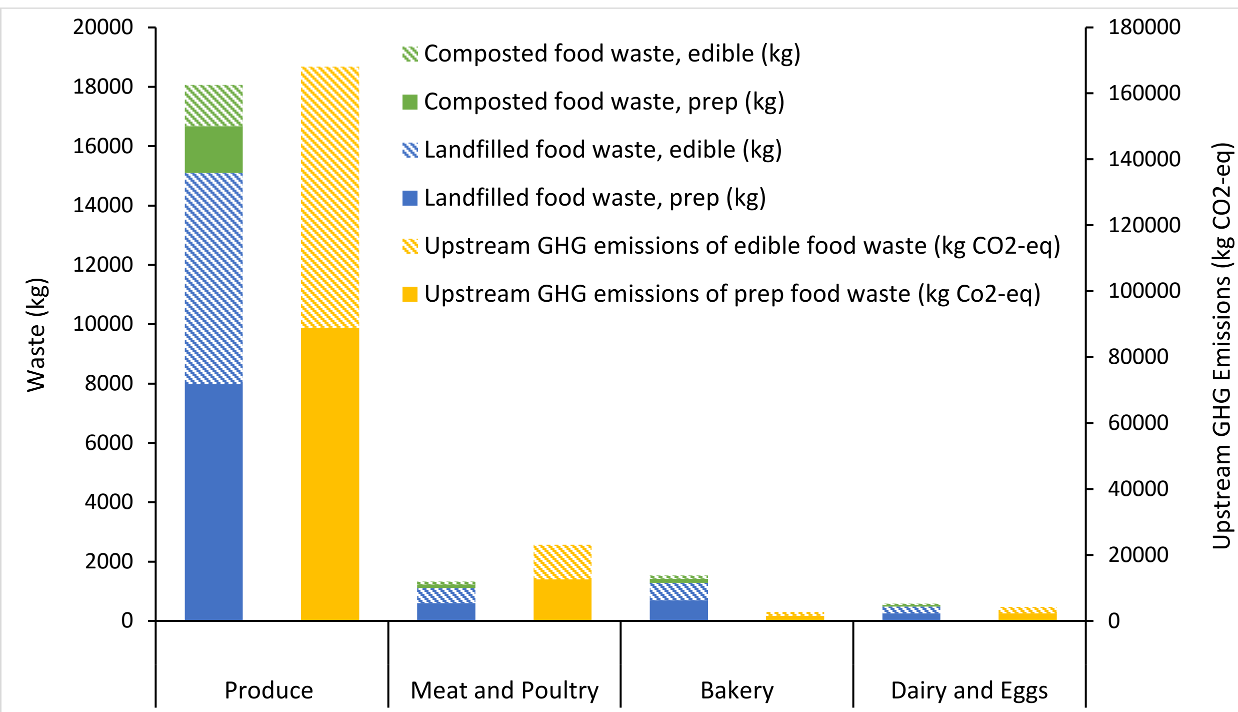

Figure 3. Food and yard waste (kg), sent to compost (green) and landfill (blue) waste streams, and the associated upstream GHG emissions (kg CO2-eq) of each food grouping (food groups contributing <1% of the total mass and emissions were not included). Total volume of food and yard waste data were derived from empirical estimates from the UBC-O Food Waste Inventory; the relative contribution of edible (dashed) and prep (solid) waste for each food grouping was estimated based on Canadian hotel and institution averages found in the Avoidable Crisis of Food Waste Canada technical report (Gooch et al. 2019). Emission factors for these food groupings were derived from the University of Michigan's database of Food Impacts on the Environment for Linking to Diets (Heller et al. 2018).

Using the WARM Tool, it was estimated that the volume of campus food waste sent to the Glenmore Landfill (i.e. post-consumer stage) between August 2019 – July 2020 emitted 11,550 kg CO2-eq of GHG emissions (Figure 4). Campus food waste sent to Spa Hills Compost for the same time period was calculated to offset GHG emissions by 430 kg CO2-eq (for details on carbon offset and emission factors used in WARM see U.S. EPA 2020). Edible waste sent to landfill emitted 5400 kg CO2-eq GHG emissions, while composted edible waste offset GHG emission by -200 kg CO2-eq. All food categories had equal GHG emissions/kg of food waste (see WARM methods for details); therefore, differences in GHG emissions between food categories within each scenario was dependent on the initial mass of each food category in the food offering inventory.

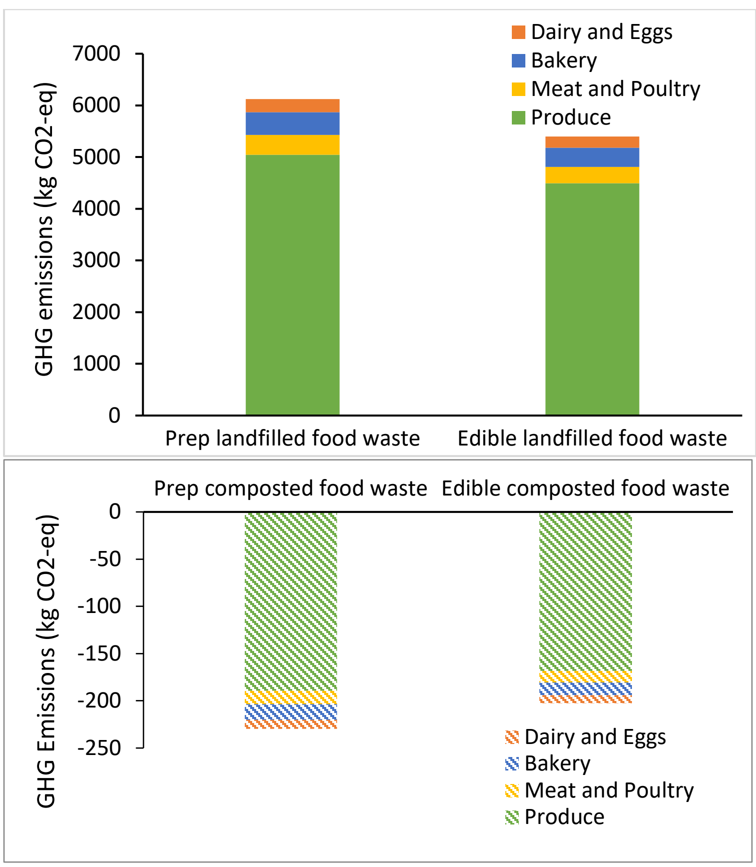

Figure 4. Post-consumer GHG emissions (kg CO2-eq) of landfilled (a) and composted (b) scenarios for edible and prep waste. Emissions broken down to four food categories based on the ACFWC report (Gooch et al. 2019): dairy and eggs, bakery, meat and poultry, and produce (food categories contributing <1% of overall emissions were excluded from this graph). Note that each food category had the same emission factor (i.e. same amount of CO2-eq

per kg of food) at the post-consumer level for landfilled food waste and for composted food waste. Therefore, differences in GHG emissions across food categories is due to the different volumes of each food group being wasted.

Waste estimates based on the UBCO Food Offering Inventory

Limited data was available for development of the UBC-O Food Waste Inventory. Therefore, alternative estimates were calculated for waste data based on the UBC-O Food Offering Inventory and are described in this section.

Total food waste was estimated to be 167,000 kg, consisting of 88,700 kg of prep waste (53%) and 78,300 kg of edible waste (47%). Upstream GHG emissions for edible and prep waste were 722 tCO2-eq and 818 tCO2-eq, respectively. 179 tCO2-eq upstream GHG emissions were produced by wasted meat and poultry (12% of total upstream emissions), while accounting for 6% (10,300 kg) of the estimated total of food wasted (Figure 5). Produce accounted for 84% (140,000 kg) of the total estimated food waste and contributed 84% (1,300 tCO2-eq) of the total upstream GHG emissions of food wasted. Figure 6 describes the percent composition of each food category to the total volume of food wasted in comparison to the total volume of upstream GHG emissions.

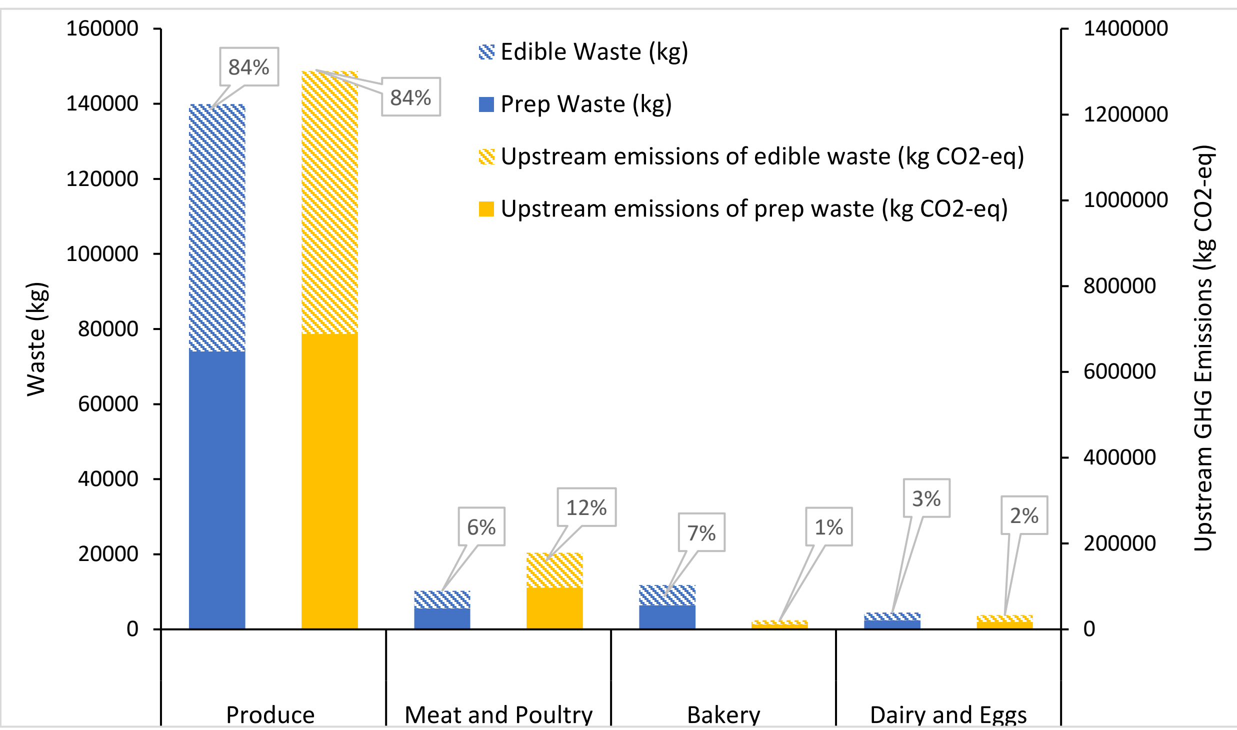

Figure 5. Mass of edible and prep food waste (kg) – estimated from the UBC-O Food Offerings Inventory – and associated upstream emissions for produce, meat and poultry, bakery, and dairy and eggs food groups (groups <1% of total waste and total GHG emissions were not shown). Data labels above blue bars indicate the percentage of the total mass of food waste (both edible and prep) for each food group. Data labels above yellow bars indicate the percentage of the total upstream GHG emissions for food waste (edible and prep combined) of each food group.

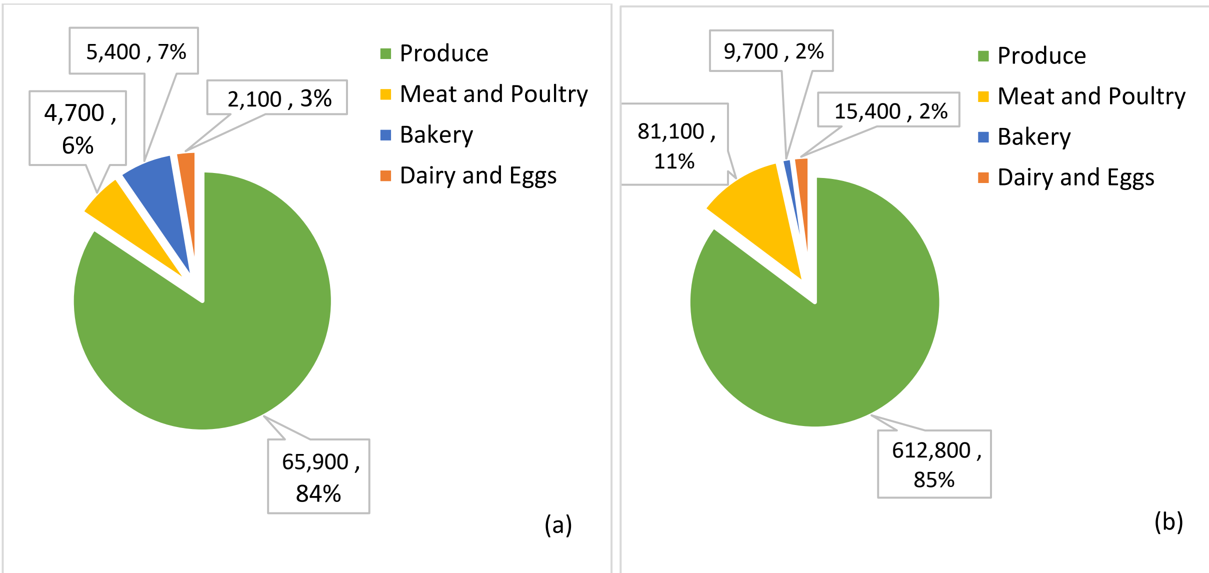

Figure 6. (a) Mass of edible food waste (kg) estimated from the food offerings inventory and (b) upstream GHG emissions of edible food waste (kg CO2-eq) for produce, meat and poultry, bakery, and dairy and eggs waste (sugars, syrups and marine food categories not shown). Data labels indicate absolute values and the percent each food group contributes to the food waste total (a) and the total associated upstream GHG emissions (b).

At the post-consumer stage, three scenarios were assessed: (1) 100% of the estimated food waste was sent to landfill; (2) 100% of the estimated food waste was composted (Figure 7b); and (3) if the estimated food waste was landfilled and composted in the ratios observed in the food waste inventory (Figure 8). In the first scenario, a total of 109 tCO2-eq GHG emissions were estimated, 47% of which was considered edible (Figure 7a). If 100% of the estimated food waste was composted, an estimated 20.7 tCO2-eq GHG emissions would be offset. In scenario three, 84% (141,600 kg) and 16% (27,800 kg) of food waste was sent to landfill and compost facilities, respectively. Post-consumer GHG emissions of landfilled food waste was 90.7 tCO2-eq. Composted food waste offset GHG emissions by 3.4 tCO2-eq. 47% of food waste and associated emissions was considered edible. Estimated edible and prep waste for all ACFWC food categories and the associated upstream and post-consumer GHG emissions are reported in Appendix C.

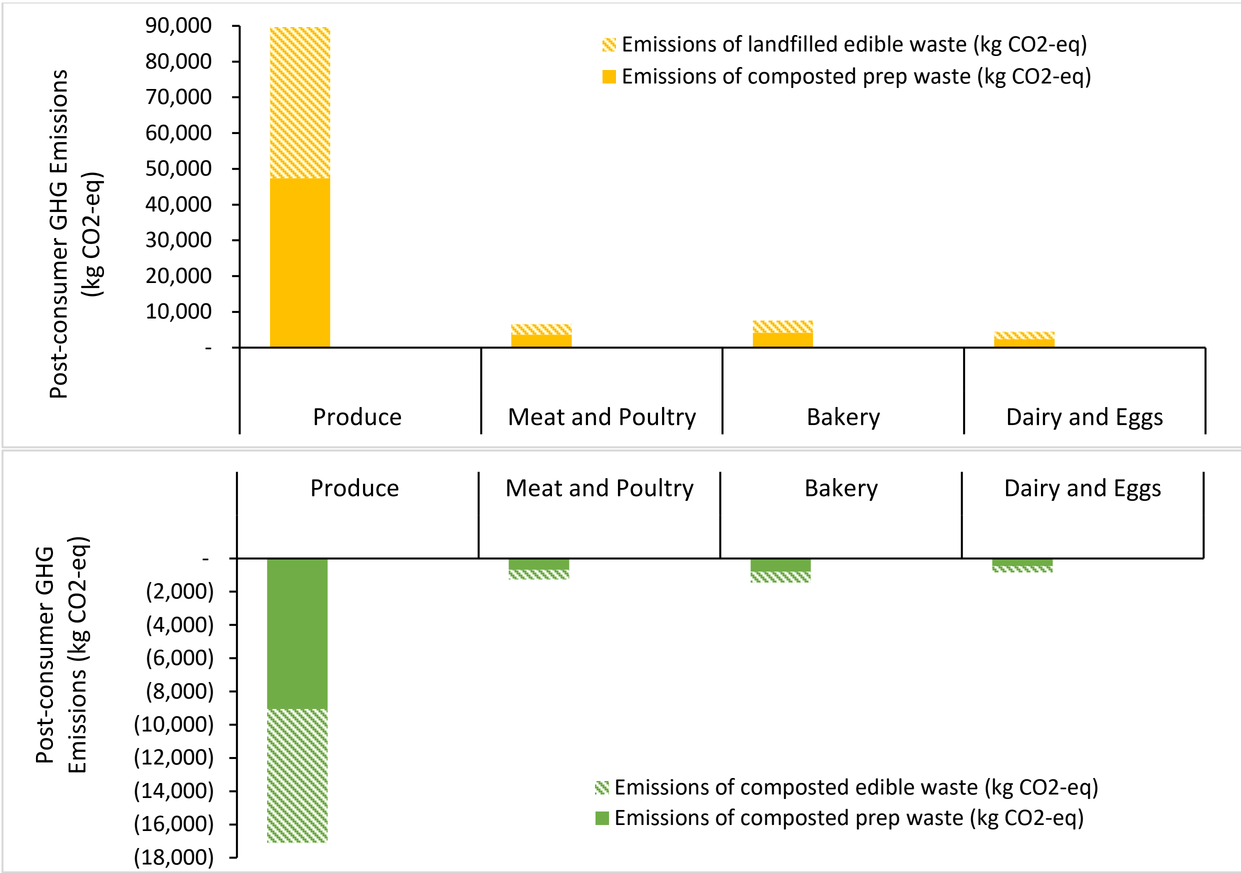

Figure 7 GHG emissions (kg CO2-eq) occurring at the post-consumer stage for prep and edible waste estimated from the UBC-O food offerings inventory. Emissions are split into two scenarios: if 100% of estimated food waste was composted (green), or if 100% of food waste was landfilled (yellow). Note that all food groups have the same emission factor; therefore, differences across food groups is a result of different volumes of food wasted in each category.

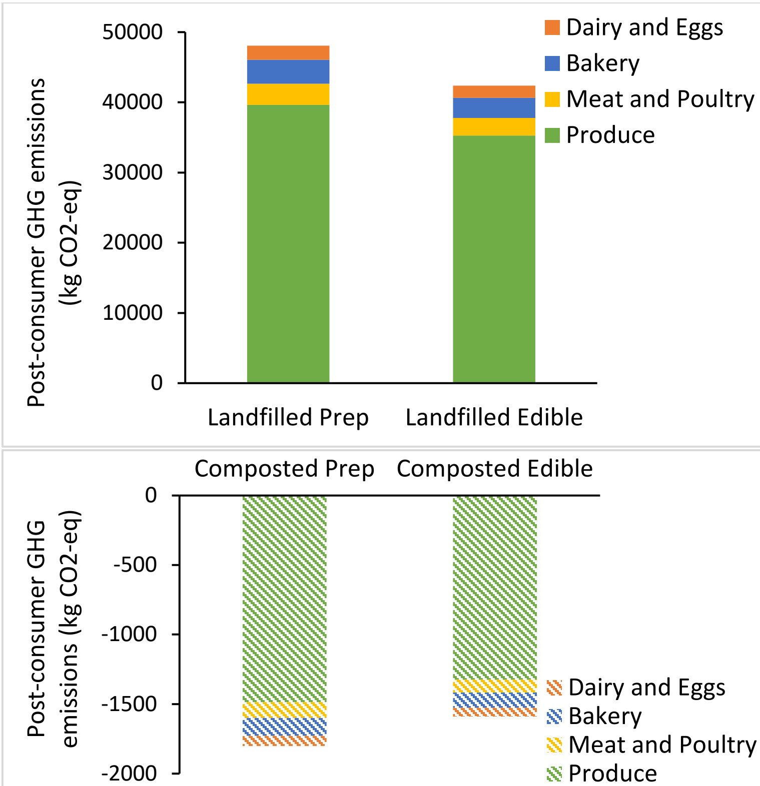

Figure 8. Post-consumer GHG emissions (kg CO2-eq) produced from edible and prep food waste volumes estimated from the UBC-O Food Offerings Inventory for four food categories (categories contributing <1% of total GHG emissions were not included). In this scenario, 84% of food waste is landfilled and 16% is composted based on the UBC-O Food Waste Inventory. Negative values indicate a GHG emissions offset.

Recommendations

UBC-O Food Services – Shifts in procurement

To optimise reductions in GHG emissions and cost savings, UBC-O Food Services should reduce procurement of food items that have a high contribution to the overall emissions associated with food services, while having a comparatively low mass contribution to the food offering inventory. It is readily apparent that beef and ruminant-derived products meet these criteria. Contributing 41% of the GHG emissions associated with food procurement while only making up 2% of the food procured, beef also had the highest GHG emissions/$ within the food offering inventory, at 8.0 kg CO2-eq/$. Plant based meat alternatives, created to mimic the sensory experience of beef products, provide an opportunity to replace beef products on campus along with an estimated 90% reduction in GHG emissions (Heller and

Keoleian, 2018). With a GHG emissions/$ value 3% that of beef, plant-based meat alternatives provide a cost-effective solution to reduce 33% of the GHG emissions associated with UBC-O's food services (a 616 tCO_2-eq per annum GHG emissions savings). Removal of beef products, with or without replacement of plant-based meats, is by far the most substantial GHG emissions mitigation strategy available for UBC-O Food Services to action and comes with the most minor modification to the food offering inventory.

Although produce follows beef as the second largest contributor (40%) to the total GHG emissions associated with the food offering inventory, it also accounts for 83% of the food procured by UBC-O Food Services. Produce therefore presents a challenge to operationalize reduction strategies. Moreover, it is unclear which items should be considered since the category encompasses a wide range of food products. It's possible that this food grouping may have significant opportunities for emissions mitigation, if future reporting is able to capture this category at a higher resolution and elucidate products with relatively high associated emissions. Further details are included in the subsequent section.

Cow and ruminant[1] dairy products are responsible for 8% (the third largest contribution) of the emissions associated with the food offering inventory. Within the inventory these products also have a relatively high associated GHG emissions per dollar value (1.06 kg CO_2-eq/$) spent by UBC-O Food Services. Plant-based products that could replace dairy products, such as non-dairy milks and plant-based cheeses and spreads, have lower emissions per dollar values (0.09 kg CO_2-eq/$ and 0.44 kg CO_2-eq/$, respectively) and provide the opportunity to mitigate 101 tCO_2-eq per annum[2] if used to completely replace dairy products. It's therefore recommended that UBC-O Food Services transitions dairy products to plant-based alternatives where possible.

[1] Dairy products included goat (ruminant) cheese
[2] Total GHG emissions of dairy products per annum (135tCO_2-eq) minus the emissions associated with the equivalent amount of plant-based cheeses and spreads (32tCO_2-eq) and non-dairy milks (1.9tCO_2-eq).

It's important to note that other high impact foods are also present in the food offering inventory but not discussed in detail due to the small fraction of the inventory that they represent. However, caution should be taken to avoid increasing procurement of these foods and substituting high impact foods, like beef, with other high impact foods. In particular, increased procurement of other ruminant derived products (like goat or lamb), crustaceans, and cocoa and chocolate products should be avoided.

UBC-O Food Services and Waste Management – avoidance of food waste

The evaluation of the UBC-O food waste inventory elucidated that significant GHG emissions reductions can be achieved in the UBC-O food system if (1) food waste of high impact foods is avoided and (2) food waste is diverted from landfill through expansion of the compost program. Findings from the food waste inventory suggested that approximately 21,600 kg of food (and yard) waste leaves campus, accounting for an estimated 199 tCO2-eq upstream emissions. Only 16% of food waste produced on campus was composted, which was shown to offset emissions by 430 kg CO2-eq using the EPA's WARM tool. The compost program on campus therefore provides a significant, but as of yet under-utilized, opportunity for GHG emissions mitigation and should hence be expanded by UBC-O Waste Management. For example, if 100% of the food waste reported in the food waste inventory was instead composted, 11.5 tCO2-eq emitted at the landfill would be avoided and the carbon offset would increase to an estimated 2.6 tCO2-eq per annum.

The percentage of food entering institutions in Canada that is wasted also varies by food group. According to the avoidable crisis of food waste technical report performed by Second Harvest, 31% of meat and poultry and 24% of dairy and eggs entering Canadian hotels and institutions is wasted, which is higher than any other food groups (Gooch et al. 2019). This constitutes a significant source of avoidable upstream GHG emissions as food items – in particular, ruminant derived products – within these broad groups are considered emissions-intensive. If we presume 31% of meat and poultry and

24% of dairy and eggs reported in the UBC-O food offering inventory is wasted, this equates to 212 tCO2-eq of upstream GHG emissions that can be avoided.

In alignment with recommendations made by the ACFW report, we recommend the following steps to reduce this avoidable food loss and associated emissions: (1) measure, manage and weigh wastes in the kitchen; (2) provide culinary staff training on lean enterprise (a practice that aims to minimize waste) and incorporate associated practices into preparation and menu design; (3) implement portion control strategies, such as the inclusion of self-serve facilities; and (4) continue to work with food rescue organizations, establish campus community food programs for rescued food, and support those that exist currently. The ACFW report also identified menu design as a driving force for plate waste in institutions, in some cases more so than portion size (Gooch et al. 2019). We emphasize the need for these strategies to be implemented with focus on commonly wasted foods that are also emissions intensive – like meat and ruminant-based products – in order to significantly reduce GHG emissions associated with avoidable waste. We also suggested that vendors on campus are held accountable, as much as possible, to the recommendations advised in this report.

UBC-O Waste Management – operational, tracking, and reporting recommendations

Empirical data for the UBC-O food waste inventory was sparse; as a result, the level of granularity achieved in this report (i.e. partitioning food waste into prep vs edible waste across six food categories) is a product of applying estimates from external resources and therefore introduces uncertainty to the results. In this report, it was assumed that food waste on campus was composed of 53% prep food waste that is not edible, and 47% edible – and therefore avoidable – food waste based on a Canadian institutional average (Gooch et al. 2019). However, it's unclear how representative this estimate is to the nature of food waste at the UBC-O campus. It is quite possible edible food is wasted in even higher proportions, as some of the food offering inventory is composed of products that are already packaged or do not require additional preparation. When estimating food waste as a percentage of the food offering inventory, this results in a conservative estimate of what is avoidable food waste. When using data from recorded compost and waste volumes, the location of data collection is an important consideration, as prep and plate food wastes will occur at different locations on campus. It is therefore critical that UBC-O implements a food waste evaluation process that captures the distinction between waste in the kitchen that is considered unavoidable, and waste from consumers that is avoidable.

This report was also limited in that it could not evaluate whether the ratio of food composted to landfilled differs between prep (kitchen) waste and plate waste. It is suspected that waste streams vary greatly between these two waste types, and it is recommended that future reporting capture these differences through location specific, annual (or more frequent) compost and waste audits.

Because the type of foods wasted on campus has yet to be captured in current tracking and reporting measures, the food offering inventory was used in conjunction with Canadian institutional averages to estimate waste for six food categories. In this way, the estimates produced were reflective of the foods offered by UBC-O Food Services, but they do not represent food waste patterns across food categories that are specific to the UBC-O campus. Produce, for example, was estimated to contribute 84% of the total food wasted on campus – not necessarily because the campus tends to waste more produce than other foods, but instead because produce makes up a much higher proportion of the food offering inventory. This impedes the determination of priority food groups when developing food waste reduction strategies. The type of food that is wasted should therefore be captured in future tracking and reporting. This will allow for identification of more frequently wasted food groups and will provide more accurate estimates of associated upstream GHG emissions.

Further study - insights on data collection, reporting, and opportunities for campus engagement

Produce accounts for 83% of the UBC-O food offerings inventory. In future reporting, it is recommended that this category be further partitioned to elucidate potentially valuable emissions reductions opportunities. In particular, this would be valuable if upstream processes are included in future reporting, where emissions-intensive activities – like air-freighted transportation, as an example – can be evaluated. Towards this end, we also recommend fostering good communication with suppliers around sustainability reporting. Expanding future study of the UBC-O Food Service procurement to include upstream supply chains will provide more representative assessment of associated upstream GHG emissions. Future reports should also be expanded to include other food operations on campus, including food trucks, contracted third party franchises and vendors, and UBC-O Student Union operated food vendors.

The recommendations for improving tracking and reporting of food waste detailed in the previous section are laudable goals that may be challenging to operationalize due to time and workforce constraints. One solution is engagement with the campus community to create stakeholder-driven projects. A student-led, volunteer-based program that assists with plate waste disposal into the appropriate waste streams can also capture data on the volumes of different food types being wasted. In this way, a higher resolution of data collection is possible, while simultaneously diverting food waste from the landfill and therefore providing a carbon offset through composting.

Further, the new Nechako dining hall presents an opportunity for expansion of our understanding of food waste patterns on campus. Data collection comparing food waste produced per capita at self-plate (Nechako) versus menu ordered (Sunshine Cafe) food operations could provide valuable insight to influence food waste reduction strategies.

Overall, the single most efficient and cost-effective way of reducing GHG emissions associated with both the food offering and food waste inventories is through the reduction of ruminant-derived products (particularly beef) provided on campus. Since these products are wasted in institutions more so than other food groups, and because their associated upstream emissions are comparatively high, reducing or eliminating them altogether would achieve significant reductions in food-related GHG emissions. Academic institutions leading on this front globally include Oxford and Cambridge Universities in the UK (Hospitality and Catering News 2020; Hoolohan et al. 2021), the Technical University in Germany (BBC 2021), and Harvard University in the US (The Harvard Gazette 2019). Bold action to eliminate beef or meat altogether from campus are to date lacking in Canada and therefore present an opportunity for UBC-O to take a leadership role and to pave the way for other Canadian institutions.

Further, this transition is easily and immediately achievable due to the wide range of plant-based alternatives that offer a similar function to their ruminant-based counterparts. UBC-O has a unique opportunity to be a leader among Canadian academic institutions in providing evidence based, climate friendly food choices and food waste stream options.

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Appendix A:

Table A1: Input details provided for EPA's WARM tool to mimic the conditions of the Glenmore landfill (pers. comm. Gordon 2021).

3. In order to account for the avoided electricity-related emissions in the landfilling and combustion pathways, EPA assigns the appropriate regional "marginal" electricity grid mix emission factor based on your location. Select state for which you are conducting this analysis.

Please select state or select national average:	Washington
Region Location:	Pacific

4. To estimate the benefits from source reduction, EPA usually assumes that the material that is source reduced would have been manufactured from the current mix of virgin and recycled inputs. However, you may choose to estimate the emission reductions from source reduction under the assumption that the material would have been manufactured from 100% virgin inputs in order to obtain an upper bound estimate of the benefits from source reduction. Select which assumption you want to use in the analysis. Note that for materials for which information on the share of recycled inputs used in production is unavailable or is not a common practice; EPA assumes that the current mix is comprised of 100% virgin inputs. Consequently, the source reduction benefits of both the "Current mix" and "100% virgin" inputs are the same.

● Current Mix
○ 100% Virgin

5. The emissions from landfilling depends on whether the landfill where your waste is disposed has a landfill gas (LFG) control system. If you do not know whether your landfill has LFG control, select "National Average" to calculate emissions based on the estimated proportions of landfills with LFG control in 2012 and proceed to question 7. If your landfill does not have a LFG system, select "No LFG Recovery" and proceed to question 8. If a LFG system is in place at your landfill, select "LFG Recovery" and click one of the options in 6a to indicate whether LFG is recovered for energy or flared.

○ National Average
● LFG Recovery
○ No LFG Recovery

6a. If your landfill has gas recovery, does it recover the methane for energy or flare it?

● Recover for energy
○ Flare

6b. For landfills that recover gas, the landfill gas collection efficiency will vary throughout the life of the landfill. Based on a literature review of field measurements and expert discussion, a range of collection efficiencies was estimated for a series of different landfill scenarios. The "typical" landfill is judged to represent the average U.S. landfill, although it must be recognized that every landfill is unique and a typical landfill is an approximation of reality. The worst-case collection scenario represents a landfill that is in compliance with EPA's New Source Performance Standards (NSPS). The aggressive gas collection scenario includes landfills where the operator is aggressive in gas collection relative to a typical landfill. Bioreactor landfills, which are operated to accelerate decomposition, are assumed to collect gas aggressively. The California regulatory collection scenario allows users to estimate and view landfill management results based on California regulatory requirements.

● Typical operation - DEFAULT
○ Worst-case collection
○ Aggressive gas collection
○ California regulatory collection

	Landfill gas collection efficiency (%) assumptions
Typical	*Years 0-1: 0%; Years 2-4: 50%; Years 5-14: 75%; Years 15 to 1 year before final cover: 82.5%; Final cover: 90%*
Worst-case	*Years 0-4: 0%; Years 5-9: 50%; Years 10-14: 75%; Years 15 to 1 year before final cover: 82.5%; Final cover: 90%*
Aggressive	*Year 0: 0%; Years 0.5-2: 50%; Years 3-14: 75%; Years 15 to 1 year before final cover: 82.5%; Final cover: 90%*
California	*Year 0: 0%; Year 1: 50%; Years 2-7: 80%; Years 8 to 1 year before final cover: 85%; Final cover: 90%*

7. Which of the following moisture conditions and associated bulk MSW decay rate (k) most accurately describes the average conditions at the landfill? The decay rates, also referred to as k values, describe the rate of change per year (yr-1) for the decomposition of organic waste in landfills. A higher average decay rate means that waste decomposes faster in the landfill.

○ National average - DEFAULT
○ Dry (k=0.02)
○ Moderate (k = 0.04)
○ Wet (k = 0.06)
● Bioreactor (k = 0.12)

	Moisture condition assumptions
Dry (k=0.02)	*Less than 20 inches of precipitation per year*
Moderate (k=0.04)	*Between 20 and 40 inches of precipitation per year*
Wet (k=0.06)	*Greater than 40 inches of precipitation per year*
Bioreactor (k=0.12)	*Water is added until the moisture content reaches 40 percent moisture on a wet weight basis*
National average	*Weighted average based on the share of waste received at each landfill type*

8a. For anaerobic digestion of food waste materials (including beef, poultry, grains, bread, fruits and vegetables, and dairy products), please choose the appropriate type of anaerobic digestion process used. Note that for grass, leaves, branches, yard trimmings and mixed organics, wet digestion is not applicable based on current technology and practices in the United States. Therefore, dry digestion is the only digestion type modeled in WARM for these ma Only one type of digestion process (wet or dry) can be modeled at a time in WARM.

○ Wet Digestion
● Dry Digestion

8b. WARM assumes that digestate resulting from anaerobic digestion processes will be applied to land. In many cases, the digestate is cured before land application. When digestate is cured, the digestate is dewatered and any liquids are recovered and returned to the reactor (when using a wet digester). Next, the digestate is aerobically cured in turned windrows, then screened and applied to agricultural fields. Select whether the digestate resulting from your anaerobic digester is cured before land application.

● Cured - DEFAULT
○ Not cured

9a. Emissions that occur during transport of materials to the management facility are included in this model. You may use default transport distances, indicated in the table below, or provide information on the transport distances for the various MSW management options.

○ Use Default Distances
● Provide Information

9b. If you have chosen to provide information, please fill in the table below. Distances should be from the curb to the landfill, combustor, or material recovery facility (MRF). *Please note that if you chose to provide information, you must provide distances for both the baseline and the alternative scenarios.

Management Option	Default Distance (Miles)	Distance (Miles)
Landfill	20	1.24
Combustion	20	
Recycling	20	
Composting	20	48.00
Anaerobic Digestion	20	

10. If you wish to personalize your results report, input your name & organization, and also specify the project period corresponding to the data you entered above.

Name	Campus Planning
Organization	University of British Columbia Okanagan

Project Period	From	05/01/21	to	09/01/21

Congratulations! You have finished all the inputs.

Appendix B:

Table B1: mass and emissions/dollar of each food category in the UBC-O food offering inventory for the Sunshine, Picnic, and Comma food providers from July 2019 to June 2020.

	Sunshine		**Comma**		**Picnic**	
Groupings	*Mass (kg)*	*Emissions per dollar (kg CO2-eq/$)*	*Mass (kg)*	*Emissions per dollar (kg CO2-eq/$)*	*Mass (kg)*	*Emissions per dollar (kg CO2-eq/$)*
High Impact						
Beef	9558	8.10E+00	16	2.53E+00	7018	7.83E+00
Other ruminants	0	0.00E+00	0	0.00E+00	398	2.56E+00
Cocoa powder	0	0.00E+00	0	0.00E+00	5	3.21E+00
Dairy - Cheese and butter	2908	4.20E+00	182	1.55E+00	4459	3.25E+00
Crustacean	63	1.24E+00	0	0.00E+00	0	0.00E+00
Medium Impact						
Chocolate	0	0.00E+00	0	0.00E+00	96	1.38E+00
Dairy - milk	3356	2.58E+00	2287	1.99E+00	8820	2.45E+00
Maple sugar / syrup	50	3.92E-01	48	4.79E-01	328	4.91E-01
Coffee and Tea	106	5.23E-02	728	1.65E-01	2	1.79E-01
Plant-based cheese and spreads	50	4.38E-01	0	0.00E+00	104	4.38E-01
Pork	1319	6.68E-01	0	0.00E+00	5	4.80E-01
Plant-based meat alternatives	310	2.68E-01	0	0.00E+00	163	2.51E-01
Egg	1638	6.03E-01	378	5.93E-01	4205	6.18E-01
Formulated bars	0	0.00E+00	0	0.00E+00	45	1.63E-01
Poultry	6885	3.69E-01	1729	5.32E-01	5635	3.00E-01
Seafood - non- crustacean	2730	1.75E-01	39	1.68E-01	425	1.06E-01
Low Impact						
Honey and Oils	3506	9.97E-01	223	8.63E-01	3342	7.84E-01
Nuts and seeds	304	8.11E-02	203	1.10E-01	237	1.30E-01
Baked goods	61	3.39E-01	0	0.00E+00	672	3.26E-01
Rice	2017	3.05E-01	577	5.71E-01	1106	6.15E-01
Juices, sauces, and vinegars	2893	2.94E-01	631	1.57E-01	7102	3.12E-01
Soy	399	2.42E-01	170	2.02E-01	464	1.98E-01
Margarine	150	3.56E-01	30	4.13E-01	67	3.76E-01
Produce	610127	4.23E+00	4103	1.73E-01	45852	2.55E-01
Legumes	3370	6.81E-01	510	4.06E-01	1402	1.75E-01
Snacks and soft drinks	0	0.00E+00	0	0.00E+00	4613	2.58E-01
Sugars	545	2.89E-01	344	1.54E-01	1407	3.97E-01
PB baked goods	359	3.32E-02	883	2.18E-02	419	3.03E-02
Grains, flours, pastas, and bread	9469	1.03E-01	887	6.20E-02	11596	9.77E-02

Non Dairy Milk	0	0.00E+00	2130	6.12E-02	3374	1.16E-01

Appendix C

Table C1: Estimated edible and prep waste from the UBC-O food offering inventory for all ACFW food categories and the associated upstream and post-consumer GHG emissions. Post-consumer emissions were calculated assuming 84% of the prep and edible mass was landfilled and 16% was composted.

		Mass (Kg)		Upstream (kg CO2-eq)		Post-consumer emissions (kg CO2-eq)			
						Landfilled		***Composted***	
Food Category	**Emission Factor**	*Prep*	*Edible*	*Prep*	*Edible*	*Prep*	*Edible*	*Prep*	*Edible*
Produce	9.3	7.40E+04	6.59E+04	6.89E+05	6.13E+05	3.96E+04	3.53E+04	-1.49E+03	-1.32E+03
Meat and Poultry	17.4	5.62E+03	4.66E+03	9.77E+04	8.11E+04	3.01E+03	2.50E+03	-1.13E+02	-9.36E+01
Bakery	1.8	6.45E+03	5.42E+03	1.16E+04	9.72E+03	3.45E+03	2.90E+03	-1.30E+02	-1.09E+02
Dairy and Eggs	15.4	3.67E+03	3.19E+03	5.66E+04	4.93E+04	1.97E+03	1.71E+03	-7.37E+01	-6.41E+01
Sugar and Syrups	2.9	1.44E+02	1.43E+02	4.19E+02	4.14E+02	8.00E+01	7.64E+01	-2.89E+00	-2.86E+00
Marine	16.9	1.30E+02	1.25E+02	2.20E+03	2.11E+03	7.00E+01	6.70E+01	-2.62E+00	-2.51E+00

Table C2: Estimated edible and prep waste from the UBC-O food waste inventory for all ACFW food categories and the associated upstream and post-consumer GHG emissions.

	Mass (Kg)				Upstream (kg CO2-eq)		Post-consumer emissions (kg CO2-eq)			
	Landfilled		***Composted***				***Landfilled***		***Composted***	
Food Category	*Prep*	*Edible*	*Prep*	*Edible*	*Prep*	*Edible*	*Prep*	*Edible*	*Prep*	*Edible*
Produce	7.88E+03	7.01E+03	1.55E+03	1.38E+03	8.77E+04	7.80E+04	5.05E+03	4.49E+03	-1.89E+02	-1.68E+02
Meat and Poultry	5.98E+02	4.96E+02	1.17E+02	9.74E+01	1.24E+04	1.03E+04	3.83E+02	3.18E+02	-1.44E+01	-1.19E+01
Bakery	6.87E+02	5.77E+02	1.35E+02	1.13E+02	1.47E+03	1.24E+03	4.40E+02	3.70E+02	-1.65E+01	-1.39E+01
Dairy and Eggs	3.91E+02	3.40E+02	7.67E+01	6.67E+01	7.21E+03	6.28E+03	2.50E+02	2.18E+02	-9.39E+00	-8.17E+00
Sugar and Syrups	1.53E+01	1.52E+01	3.01E+00	2.98E+00	5.33E+01	5.28E+01	9.83E+00	9.73E+00	-3.68E-01	-3.65E-01
Marine	1.39E+01	1.33E+01	2.72E+00	2.61E+00	2.80E+02	2.69E+02	8.89E+00	8.53E+00	-3.33E-01	-3.20E-01