Estimating Greenhouse Gas Emissions from Food: A Case Study on the City of Vancouver's Food Procurement Practices

Prepared by: Poushali Maji, UBC Sustainability Scholar, 2019

Prepared for: Caitlin Dorward, Social Planner, City of Vancouver

Rachel Telling, Sustainability Specialist, City of Vancouver

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Executive Summary

Strong action to reduce greenhouse gas emissions (GHG) is needed to avoid the devastating impacts of climate change. The City of Vancouver, along with a number of other cities, has set a number of ambitious GHG emission reduction targets across sectors such as buildings and transportation. Currently, however, the GHG impact of food systems is not included in Vancouver's climate action plans.

The majority of food production occurs outside of Vancouver's city limits and common emission accounting protocols have generally only included emissions that are under direct control of the City – emissions occurring within city limits and those associated with purchased energy. Given the significant GHG footprint of a Vancouver resident's food consumption and the leadership impact municipal policy can have on residential food consumption patterns, reducing the GHG impact of municipal food procurement can be a noteworthy step for the City of Vancouver.

This project aimed to assess the GHG impact of the City's food procurement and identify policy priorities, taking into account the work of other municipalities in this area as well as the equity challenges associated with implementing dietary changes within institutional food provision.

A review of literature on food systems revealed that dietary choices are more significant in determining GHG emissions impact compared to whether food is imported or grown locally. In general, animal-based food products are more GHG intensive compared to plant-based food products. Meat from ruminant animals (beef and lamb) is at the top of the hierarchy of GHG-intensive foods, followed by pork, and then processed dairy such as cheese and butter. Chicken and eggs have lower GHG impacts than most animal products, while the GHG impact of fish is highly variable depending on species and mode of fishing. Fruits, vegetables, grains and legumes generally have low GHG intensity; with the exception of greenhouse grown produce, whose GHG impact can be comparable to animal products like eggs, particularly in cold climates due to high heating requirements.

A scan of municipal policies related to food sustainability in developed countries showed that the general focus is supporting the local food economy, providing equitable access to food, and reducing food waste. Policies focusing on dietary shifts are slowly gaining traction but are yet to become part of the mainstream discussion on food sustainability – a number of cities have adopted programs that include reducing meat consumption in public facilities like schools and hospitals and increasing the number of vegetarian options on menus.

A quantitative assessment of the City of Vancouver's available food procurement data – that procured by Vancouver Parks Board and three low cost meal providers – showed that about 71%

of GHG emissions associated with municipal food procurement are due to beef and pork consumption. A further scenario analysis showed that substituting beef and pork with lower carbon options such as legumes and chicken could reduce GHG emissions by 69% and 55% respectively. A “Meatless Monday” scenario in which meatless meals are served on only one day of the week can reduce GHG emissions by 11%. In contrast, a transition to locally grown produce only reduces GHG emissions by 7%.

A qualitative assessment of the City’s typical catering menus showed a similar high proportion of meat-based meals. Although a quantitative analysis was not possible for this area of food procurement, a similar reduction of GHG emissions can be expected with transitions towards plant-based catering menus.

This work acknowledges that although the GHG advantage of procuring local produce may not be substantial, there are other benefits of a thriving local food economy that are beyond the scope of this project to discuss. Some limitations of this work include gaps in data reporting such as details on greenhouse produce, region of import and purchases by other procurement avenues such as catering.

This analysis, along with previous studies on food systems, suggests that the most effective GHG emission reduction strategy is a dietary shift away from meat, particularly beef and pork. This finding aligns with the recently published *EAT*-LANCET (2019) report which concludes that a transition towards a diet that consists of mostly plant-based foods is not only good for individual health but also for planetary health.

Given the range of food procured by the City of Vancouver, if the City chooses to implement procurement changes associated with these findings, strong partnerships with stakeholders will be required to understand dietary preferences as well as sensitivity towards existing inequities among clientele in terms of exercising dietary choices.

Introduction

Recent findings of the Intergovernmental Panel on Climate Change (IPCC) conclude that limiting global warming to 1.5°C above pre-industrial levels is necessary to reduce many devastating impacts of climate change including species extinction, sea level rise, and life-threatening weather extremes (IPCC, 2018). To maintain the 1.5°C threshold will require ambitious reductions in global greenhouse gas (GHG) emissions across all sectors.

The City of Vancouver, in line with the IPCC's call to take critical action on climate change adaptation and mitigation, has joined other cities globally to set measurable targets for reducing its local GHG emissions through the Greenest City Action Plan, Renewable City Action Plan and more recently the Climate Emergency Response Report.

The City's climate action has focused on reducing GHG emissions the City has the greatest control over -Scope 1 GHG emissions (which are direct emissions from sources located within the city boundary) and Scope 2 GHG emissions (which are associated with the generation of grid-supplied energy used within the city boundary). Scope 3 GHG emissions (which include emissions occurring outside the city boundary due to activities taking place within the city, such as food consumption), are being considered for inclusion in updates to City policies and are receiving increasing attention in international forums such as C40 Cities, a network of 94 cities committed to taking bold climate action. Currently, City of Vancouver's overarching food policies, including the Healthy City Strategy and Vancouver Food Strategy, focus on ensuring equitable access to healthy and local food, and do not specify food-related GHG emission reduction targets.

GHG emissions associated with the food system (including food production, processing and distribution, sales, consumption, and waste management) are estimated to account for 15-30% of a developed country's national GHG emissions (Garnett, 2011). However, limited food production occurs within Vancouver's city limits, and a production-based approach towards calculating a city's food GHG emissions only includes emissions directly associated with activities within the city boundary, excluding the contribution of residents' food consumption.

A consumption-based accounting framework, which includes emissions of commodities imported from outside the city limits, can help us better understand the total impact of food and other commodities consumed within the city as well as the range of actions city governments can take to influence residents' consumption patterns. A recent report from C40 Cities (2018) identifies food as the largest GHG emission source in C40 cities, including Vancouver, if consumption-based categories are included in GHG accounting. The food system accounts for 51% of a Vancouver

resident's ecological footprint (V. Timmer & Timmer, 2017), i.e. the net impact of all human activities in terms of resources required, a significant component of which is the GHG footprint.

This project aims to explore opportunities for the City of Vancouver to reduce food system GHG emissions associated with its own food purchases. Municipal food procurement provides an excellent case study of the GHG impact of food systems due to the ready availability of data on specific foods purchased, and directly actionable policy approaches to consider. The City of Vancouver can position itself as a sustainability leader by taking GHG reduction action in its own food procurement, which would then demonstrate best practice to individuals and businesses.

The specific objectives of the project are to:

- Conduct a scan of other municipalities' work (e.g. policies and strategies) to reduce GHGs from food consumption;
- Conduct a literature review of food GHG emissions considering food type, production, and transport processes;
- Develop a framework to estimate GHG emissions from City food procurement (specifically Vancouver Parks Board and the City's low cost meal providers);
- Based on results from the emissions estimate and municipal food policy scan, identify policy priorities for the City of Vancouver

This research project recognizes that while some residents of Vancouver are able to exercise "choice" in the types of food they consume, this is not the case for all. Residents living on low incomes or in poverty, and those affected by systemic inequities, often cannot access affordable, nutrient rich foods and lack agency over the types of foods in their diet. These same members of our society are often most greatly impacted by the population health impacts of environmental degradation, and have fewer resources to respond and adapt. Furthermore, food consumption is inherently linked to cultural backgrounds and practices and can be shaped by religious beliefs, health conditions, and personal values. Within this context, additional policy changes related to food procurement must be informed by strong partnerships with stakeholders and sensitivity towards existing inequities among the residents that the city serves. Given the role of municipal food procurement, the City needs to provide nutritious and culturally relevant food that is concurrently good for the planet.

Drivers of GHG emissions in food systems

GHG emissions – including carbon dioxide, methane and nitrous oxide – are by-products of food system processes at all stages. Food system processes include production, processing, packaging and distribution of products, consumption and waste. GHG impacts at each of these stages are outlined in Table 1.

Table 1 Drivers of GHG emissions in food systems

Food System Stage	Sources of GHG Emissions
Production	Fossil fuel for machinery and greenhouse production
	Fertilizer manufacturing
	Soils/fertilizer application
	Livestock – enteric fermentation[1]
	Livestock – manure management
Processing and Distribution	Fossil fuel for machinery used in milling, canning, processing etc.
	Fossil fuel inputs for packaging
	Transportation
Consumption	Retail services (e.g. refrigeration)
	Cooking
Waste	Disposal (e.g. landfill gas)
	Material recovery
	Wastewater treatment

The following process diagram adapted from the work by Mohareb et al. (2018) outlines the sources of GHG emissions at these different stages in the food system.

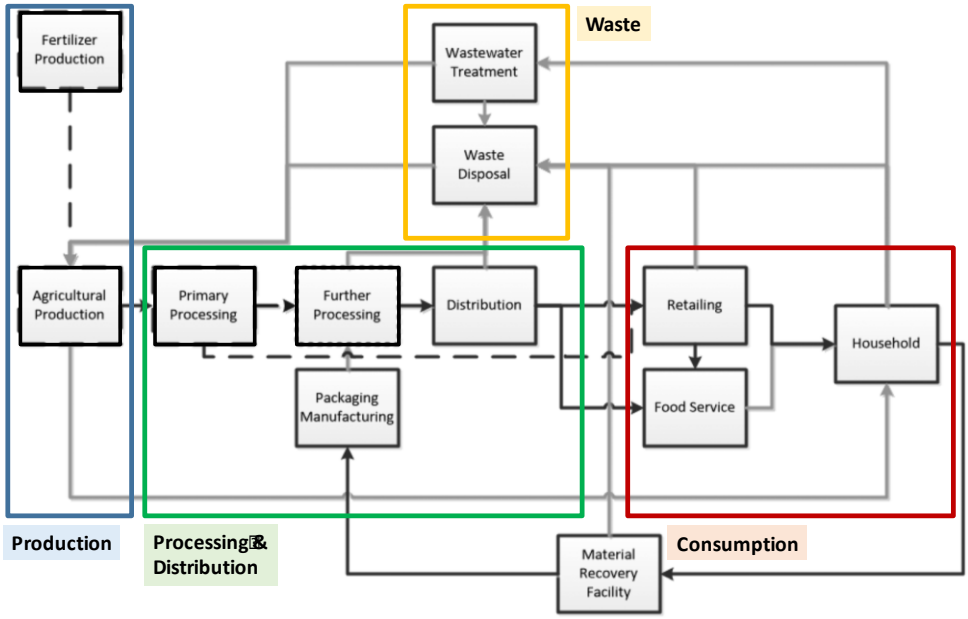

Figure 1: Process diagram for food system GHG emissions (Adapted from (Mohareb et al., 2018))

In this project we focus on estimating GHG emissions from food procured by the City of Vancouver, and therefore focus our literature review on the following emission reduction leverage points:

- Food Production: GHG intensity of food groups and mode of production (for example, fertiliser use and fossil fuel input needed)
- Distribution ("Food Miles"): distance transported and carbon intensity of transport
- Waste: Food waste at distributor and vendor level

Food production

It is widely accepted that the most GHG intensive portion of the food system is the production stage (Chen, Tucker, Badami, Ramankutty, & Rhemtulla, 2016; Clune, Crossin, & Verghese, 2017; Garnett, 2011; Heller & Keoleian, 2014; Mohareb et al., 2018). In an analysis of urban policies to mitigate food-related GHG emissions in the US, Mohareb et al. (2018) conclude that the production stage accounts for about 50% of life cycle emissions and hence the greatest GHG emission reduction potential is in transitioning away from foods that have a high GHG production intensity.

A review of life-cycle assessment studies on GHG emissions for different food groups (Clune et al., 2017) recognises the clear hierarchy in GHG intensity of food groups – meat from ruminant

animals such as cows and sheep is the most GHG intensive (primarily because of methane produced during enteric fermentation in addition to high feed and land requirements), while grains, fruits and vegetables are the least. Eggs and chicken lie in the middle of the GHG impact spectrum, while the reported climate impact of fish is highly variable across studies depending on species and method of fishing. Milk and yogurt have higher GHG footprints than most plant products, while cheese and butter have even higher footprints, second only to meat from ruminants in the hierarchy.

The mode of production also affects emissions impact. For example, the climate impact of greenhouse produce is 3-5 times higher than that of field grown vegetables depending on heating requirements and hence the geographical region of production.

Thus a hierarchy of GHG intensity can be established for food groups as presented in Figure 2.

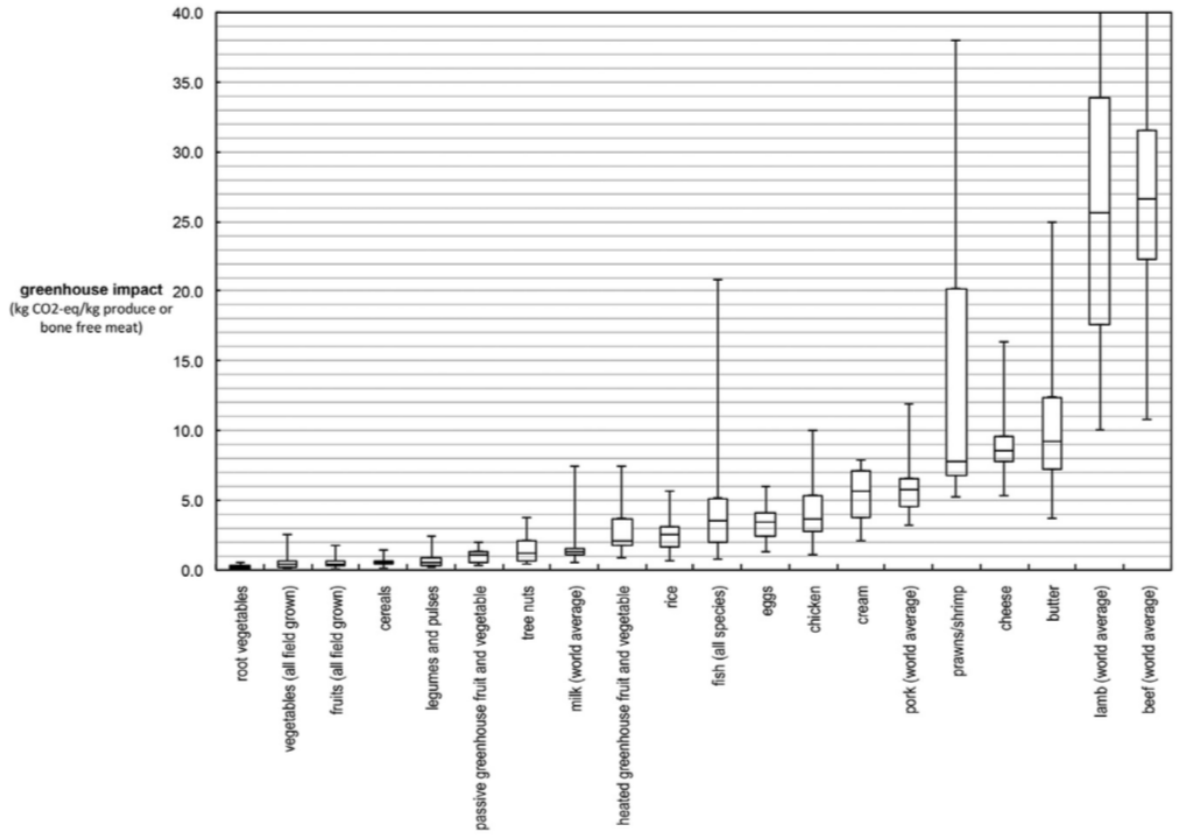

Figure 2 Hierarchy of GHG emissions impact for food groups (Source : (Clune et al., 2017))

Distribution ("Food Miles")

An analysis of food miles associated with food groups for consumption in different parts of Canada (Kissinger, 2012) found that fruits and vegetables had the highest transport-related emissions and accounted for 25% of total food mile-related emissions in Canada. While import of meat, fish, and dairy account for about 7% of food mile-related emissions, grains and grain products accounted for 16% of the total (Kissinger, 2012). However, it is difficult to accurately estimate GHG emissions related to transporting food products to Vancouver due to poor trade data, and multiple import locations and sources of food.

Kissinger et al. (2018) in their study specific to south-western BC conclude that most locally produced fruits and vegetables provide a carbon advantage over their imported counterparts, while there are no carbon advantages of locally produced meat and dairy products, primarily due to the reliance on imported feed grain and high land requirements. A case study of meals in Quebec (Thibert & Badami, 2011) shows that plant-based (vegan) meals made with ingredients imported from North America and China are less GHG intensive than meat (pork)-based meals made with locally sourced ingredients.

Waste

Consumer-level food waste varies across countries. Estimates of the portion of total food bought that is ultimately wasted range from 22% in the UK to 24% in Canada to 40% in the USA, (L. J. Dorward, 2012; Second Harvest & Value Chain Management International, 2019). Reducing food waste is significant from the perspective of reducing GHG emissions for two reasons. Firstly, reducing the embodied GHG in wasted food (i.e. emissions involved in across the whole food system for food that is ultimately wasted) and secondly, reducing emissions from waste disposal (i.e. methane emissions from landfills).

Heller and Keoleian (2014) compare GHG emissions from high carbon intensity food groups such as beef to those from food 'loss', including waste and spoilage, at the consumer and retail level in the US (without accounting for landfill emissions). They found that GHGs avoided by eliminating retail and consumer level losses (28%) are comparable to the reductions from transitioning to a vegetarian diet (30%). Food wasted at the production stage itself accounts for about 14% of food system GHG emissions in the US, while food waste disposal in landfills accounts for 12% (Mohareb et al., 2018). Hence reducing food waste and diverting waste away from landfills provides significant GHG emission reduction potential.

The most GHG intensive method of waste disposal is landfilling, while the least GHG intensive method involves using food waste for a productive purpose such as animal feed or production of

biofuels (L. J. Dorward, 2012). Composting can lead to net negative GHG emissions if fertilizer offset (through replacement with compost) is considered, and is less energy intensive compared to landfill unless landfill gas is recovered and used to displace fossil fuels in the power grid (Levis & Barlaz, 2011).

Discussion

A review of global and national level studies on food-related GHG emissions (Garnett, 2011) shows that dietary shifts (away from GHG-intensive food groups such as meat and dairy) play a bigger role in reducing food supply chain GHG emissions than technological approaches such as reducing fertiliser use or reducing the carbon intensity of fuel inputs. Compared to production-phase GHG emissions, which account for 83% of total food system GHG emissions in the US, GHGs associated with the distribution of food only account for 11% (Weber & Matthews, 2008).

Studies comparing the environmental impact of meals (Chen et al., 2016; Thibert & Badami, 2011) conclude that food choices have a greater impact on GHG emissions than whether food source is local or imported. Specifically, beef, lamb and cheese have the highest GHG intensity, while eggs are the lowest among animal products and comparable to some plant foods such as greenhouse grown vegetables. For some foods, such as soy and rice, the source of production has a significant impact on GHG emissions, distinct from transport-related emissions, due to variations in land and fertilizer requirements. Both studies mentioned show that imported ingredients added marginally to total energy budget of a plant-based (vegan) meal compared to local ingredients.

These studies provide just a few examples of research demonstrating that dietary shifts can more effectively reduce food system GHGs than buying local food. However, the mode of production, i.e. whether food is grown in greenhouses and out of season or on fields in-season, affects GHG emissions significantly. The energy intensity of greenhouse production of plant-based produce is significantly higher compared to importing ingredients or fertilizer use, particularly in cold climates – for example, greenhouse produce in Quebec required 50-56% more energy compared to field grown produce (Chen et al., 2016) and more energy than the most energy intensive meal (meat-based organic) (Thibert & Badami, 2011).

Thus food type, source, and mode of production are primary contributors of GHG emissions from production processes. In addition to this, depending on the level of food waste and the waste disposal method, embodied GHG emissions in food and emissions associated with landfills make food waste a target area for GHG emission reduction action. GHG emissions arising from consumption (for e.g. cooking and refrigeration) are not highlighted as major emission sources in literature and are outside the scope of this work.

Municipal policies and strategies to reduce food-related GHG emissions

Currently Vancouver's food policies, as outlined in the Healthy City Strategy and Vancouver Food Strategy, do not include specific targets for reducing food-related GHG emissions, and instead focus on ensuring equitable access to healthy, local and sustainable food. However, actions to reduce food-related GHG emissions align with the City's broad climate action goals.

A municipal food policy scan was conducted by reviewing 23 documents focusing on GHG emission reduction policies from three databases:

- Actions taken by signatory cities to the Milan Urban Food Policy Pact (MUFPP). MUFPP is a global agreement signed by 199 cities, including Vancouver, to create resilient urban food systems;
- Growing Food Connections Local Government Policy Database of local government policies in Canada that address community food system issues, specifically public procurement and access to healthy food; and,
- Kwantlen Polytechnic University's British Columbia Food System Policy Database on local government policies that address local food system issues, specifically public procurement and sustainable food.

The food system GHG emissions reduction policies found in this scan generally focused on diversion of food waste from landfills to composting facilities (which reduces methane emissions), and on reducing transport sector GHG emissions by reducing food imports. For example, in the municipality of Riga (Latvia), food waste is used as an input to a waste-to-energy facility and the heat generated as a by-product fuels greenhouses used to grow off-season tomatoes and cucumbers. A number of municipalities in Canada, including Kamloops (BC), Hamilton (Ontario), Victoria (BC) and Squamish (BC), promote diverting food waste from landfills towards composting facilities through subsidised community and backyard composters and educational resources for residents. Composting is a less GHG intensive method of food waste disposal than landfilling (L. J. Dorward, 2012), and it has the added benefit of creating a by-product (soil/compost) which can be used to return nutrients to the soil or replace energy-intensive fertilisers.

In addition, a number of municipalities (including Kamloops (BC), Bowen Island (BC) and Calgary (Alberta)), aim to reduce GHG emissions associated with transport of imported food and hence support urban agriculture and local food procurement policies as a means to reduce food GHG emissions. Given that local foods are not always less GHG intensive, the impact of these policies

on GHG emissions is debatable. However, supporting local food production and procurement has other positive benefits that are recognized by some municipalities. The municipality of Campbell River (BC), for example, recognises that locally-produced foods are not always less GHG-intensive, but that local food plays a role in strengthening the economy and reducing insecurity arising from rising energy prices and global climate change.

Only a few of the municipal policy documents reviewed targeted the role of dietary shifts in reducing the food system's climate impact. One example is the city of Portland's (USA) Climate Action Plan (2009) which includes reducing consumption of carbon-intensive foods like red meat as a key objective for 2030 along with promoting local food, composting, and reducing food waste. In the city of Vienna (Austria), food procurement through the EcoBuy Vienna program for meals provided in public facilities (such as day care centres and hospitals) follows high standards stipulated according to criteria for nutrition, environment and cost-effectiveness, and includes reduction of meat and food waste. Copenhagen's (Denmark) Organic Conversion Policy and New York City's (USA) Green New Deal include reducing meat served in municipal canteens and schools as a key component of GHG emission reduction plans. The Meatless Monday program, in which no meat-based food is served on Mondays, has been introduced in a number of schools, hospitals, companies and restaurants around the world - public schools across New York City adopted the program in March 2019 as part of the City's initiative to provide free healthy meals to students that are concurrently good for the planet.

From a health perspective, policies adopted by municipalities suggest a general acceptance that foods with smaller environmental impacts (eg: fruits and vegetables) also offer greater health benefits than those with larger environmental impacts (eg: meat). One noteworthy program is the Good Food Purchasing Program (GFPP)- a policy framework aimed to assist institutions in procurement of food that is local, healthy, sustainable and humanely sourced. It has been adopted by a number of municipalities and school districts in the USA (including Los Angeles, San Francisco, Chicago and New York City). Most recently, Boston City Council adopted the GFPP (March 2019) – this implies that food served to students through the Boston Public School system, the largest food purchaser in the municipality, will need to meet specific standards for nutrition, environmental sustainability, animal welfare and local ethical sourcing. The environmental sustainability standards that form part of the program emphasize increasing low-carbon menu options, improving energy efficiency and reducing food waste, among other measures related to promoting local, healthy and ethical food.

Although the conducted scan was not exhaustive of all municipal food-related policies, the focus of sustainability in public procurement of food has generally been local or organic, and dietary shifts are yet to be part of the mainstream discussion on equitable access to sustainable healthy

diets. The policy scan conducted revealed that most municipal food policies in British Columbia and other developed countries (for example, Baltimore (USA), Melbourne (Australia), Birmingham (England), and Philadelphia (USA)) focus primarily on three goals : strengthening the local food economy by promoting urban food production (e.g. Victoria) or increasing local food procurement for municipal-owned facilities (e.g. Hamilton) ; ensuring access to healthy fresh food for all citizens (e.g. financial incentives to grocery stores in under-served neighbourhoods in New York City); and reducing food waste (e.g. Vancouver). While these policy priorities play a significant role in ensuring food security and equitable food access, from a climate perspective, the literature confirms that a dietary shift away from meat and dairy is the most effective strategy in reducing GHG emissions.

Methods for estimating GHG emissions from the City's food procurement

Procurement streams

The City of Vancouver's food procurement includes several aggregated and disaggregated streams, as follows:

- Facilities run by Arts, Culture, and Community Services (three low cost meal providers) and the Parks Board (golf courses, concession stands and community centres), which together account for about 60% of City's food purchases by dollar value (Craig, 2014).
- Catering for meetings and events (which is disaggregated across city departments with no centralized coordination); PNE and Vancouver Civic Theatres (which primarily procure packaged snack foods and beverages); and VPD, VPL and Vancouver Fire & Rescue (which have their own governance models). Together these account for about 40% of the City's food purchases by dollar value (Craig, 2014).

Qualitative assessment of catering menus

Data on food procured for catering at City events and meetings was not available, primarily due to the fragmented nature of catering activities. Given this limitation, a qualitative review of the menus of most commonly used caterers was completed in order to identify potential GHG emissions leverage points within this procurement stream.

Quantitative assessment of procurement data

For the purpose of this project, data was available on quantity and types of food procured in 2018 by Vancouver Parks Board and the City's three low cost meal providers (Carnegie, Gathering Place and Evelyn Saller Centres). Data was provided by the Inventory Planner, Supply Chain Management, at the City of Vancouver.

Food groups and quantities procured

The available dataset on food items (raw and processed) was grouped into the following categories:

- Grains (including bread, pasta, etc.)
- Legumes (including tofu)
- Fruits (including juices)

- Vegetables (including processed products such as ketchup)
- Non-dairy milk and cheese
- Dairy (milk, yogurt, cheese and creamer)
- Eggs
- Fish
- Meat (chicken, turkey, pork and beef)
- Nuts, butter and oils

The above food groups account for about 80% of food procured by weight (as well as about 80% by volume for beverages like milk and juice). The remaining 20% consists of soft drinks, spices, and processed and packaged foods without an identifiable single key ingredient (for example cookie dough and sauces). Due to uncertainty about the contents of these products, they were excluded from this analysis.

Data cleaning/processing

Recorded item weights and volumes were converted to weights in kilograms and volumes in litres to standardise the data. In cases where item quantities were available in terms of item count (for example, number of melons purchased) and not in item weight, counts were converted to weights using data from the Canadian Nutrient profile (detailed conversion factors available in the Excel workbook). For processed (milled, canned, frozen or pureed) food items that have a single easily identifiable key ingredient, conversion factors to estimate the equivalent weight of original food item (for example, tomatoes) needed to produce the recorded weight of processed items (for example, ketchup) were provided by the Institute for Sustainable Food Systems at Kwantlen Polytechnic University. Conversion factors were those used in their Southwest BC Bioregion Food System Design Project (C. Dorward, Smukler, & Mullinix, 2016).

Production location: Local and imported food

Data was available from all three low cost meal providers and Vancouver Parks Board on whether each food item procured is locally produced or imported. 'Local' food is defined as food items that are produced or processed in British Columbia. For the purpose of this project food items processed in BC but with key ingredients produced outside of BC (for e.g. locally produced bread with wheat flour produced outside of BC) are not considered local. With a few minor exceptions, there is no data available on the region of origin for imported items. As such, location-specific production GHG emissions or transport-related emissions of food items could not be estimated. Instead, estimates in this analysis rely on emission factors from literature specific to BC imports as noted in the next section.

Production mode

There was limited data available on the mode of production – eg: field grown vs. greenhouse produce, organic vs. non-organic – for plant-based produce items. The only exception is greenhouse grown tomatoes and lettuce in the dataset provided by one low cost meal provider. For the purpose of this project, all items are considered field grown unless stated otherwise. Since greenhouse-grown produce has higher GHG emissions than field produce, this analysis may underestimate GHG emissions from certain fruits and vegetables procured.

GHG emissions estimation

The following formula was used for estimating GHG emissions from all food items *(i)* and services *(s)* for which quantitative data on food purchased in 2018 is available (i.e. Vancouver Parks Board and low cost meal providers):

$$\sum_{s,i} GHG_i \quad = W_i \; x \; emf_i$$

- Where GHG_i = GHG emissions from the total amount purchased of each food item,
- W_i = Weight of each item (in kilogram) or volume in litre
- Emf_i = emission factor associated with each item (emissions per kilogram or litre of item).

Emission factors

Emission factors for each item were obtained from two studies: Kissinger et al. (2018) and Clune et al. (2017).

The study by Kissinger et al. (2018), which was also part of the Southwest BC Bioregion Food System Design Project and thus specific to the southwest BC food system, provides emission factors for a range of fresh foods, both locally produced in British Columbia as well as imported from outside of BC. The relevant (local or imported) emission factors were applied to locally sourced and imported items. The emission factors are specific to food production and import-related transport, and do not include emissions associated with processing (for example, milling of flour or canning of tomatoes).

Food items for which emission factors were not available from the above study (for example, pork, chicken, fish products and a number of vegetables) were obtained from the study by Clune et al. (2017). Clune et al. (2017) conducted a systematic literature review of studies on the greenhouse gas impact of 369 food items across the world. Although the emission factors from this study are not specific to BC or the region of imports for each food item, they provide

relevant data points in the absence of BC-specific data. For local items procured, Canadian or North American specific emission factors from this study were used.

Scenario Analysis

A scenario analysis was conducted to help inform our understanding of the potential for various changes in municipal food services to lead to GHG emission reduction. To calculate emissions reductions associated with the scenarios, a food group is substituted with another of relatively lower emission factor in each scenario, and re-calculated GHG emissions are compared with estimated GHGs from the actual food procurement.

As summarized in Table 2, the following scenarios were considered:

- Substituting all beef and pork with legumes

  Beef and pork are the most GHG-intensive food items, and although it may not be possible to fully transition to plant-based protein such as legumes, this scenario explores the theoretical GHG emission reduction potential in shifting away from beef and pork.

- Substituting all beef and pork with chicken

  The average emission factor for chicken (emissions per kilogram of meat) is about 40% and 80% less than that for pork and beef respectively. This scenario explores transitioning from high GHG meat options like beef and pork to a low GHG meat option like chicken.

- Meatless Monday

  Although a meat-less diet might be most effective in reducing GHG emissions, it may not be practically feasible to implement uniformly across municipal food services. This scenario explores the impact of serving meatless meals in the City's food services on just one day of the week i.e. Meatless Monday, a program widely adopted in a number of schools and hospitals to date. In this scenario, meat (beef, pork and poultry) consumption data is reduced by one-seventh in order to simulate serving meat-less meals on one day of the week; this assumes that food purchases recorded in the dataset occur uniformly across the week and that serving meatless meals will not affect the volume of purchases.

- Substituting dairy with legumes

  Milk has a higher GHG emission factor than most plant-based foods (except greenhouse grown produce and rice); furthermore, dairy products like cream, butter and cheese are second only to pork and ruminant meat (beef and lamb) in terms of GHG emission factor. This scenario estimates the GHG emission reduction potential in substituting all dairy

products with plant-based protein such as legumes (for e.g. substituting a serving of cheese with cooked beans).

- Transitioning from imported fruits and vegetables to locally grown fruits and vegetables (where possible)

  Imported fruits and vegetables generally have higher emissions associated with them due to emissions associated with transport of produce and sometimes due to different agricultural practices in the production region. In this scenario, imported fruits and vegetables in the food procurement dataset are substituted with their local equivalents and corresponding BC-specific emission factors from the study by Kissinger et al. (2018) are associated with them, if they can be grown in BC. This helps examine the GHG emission reduction potential of a policy promoting the procurement of local produce where possible.

- Reducing total meat and dairy consumption to meet EAT-LANCET daily dietary guidelines by weight

  The *EAT*-LANCET report (2019) provides guidelines for a diet that is healthy for both individuals and the planet. The guidelines point towards the majority of our dietary needs being met from plant-based sources, with minimal animal based foods. In this scenario, the ratio of different food groups by weight is calculated from the annual procurement data by each service. We assumed that all clients access the service daily and for all meals, and hence the annual food group distribution also represents the daily food group distribution. We recognise that this assumption is not expected to hold true for municipal food services but consider it necessary to illustrate the impact of this scenario.

Table 2 Summary of scenarios considered for GHG emission reduction

SCENARIO	RATIONALE
Beef and pork → legumes	Substitute the most GHG intensive animal-based foods with low GHG plant-based protein
Beef and pork → chicken	Substitute the most GHG intensive animal-based foods with relatively low GHG animal-based food
Meatless Monday	Serve meatless meals on one day of the week
Dairy → legumes	Substitute high GHG dairy with low GHG plant based protein
Imported → local produce	Substitute imported produce with local (where possible) to reduce transport-related GHG emissions
EAT-LANCET guidelines	Reduce meat and dairy consumption to meet *EAT*-LANCET dietary guidelines

Results

Qualitative assessment of catering menus

The qualitative assessment revealed that menus generally had a majority of meat and dairy-based items, and meat-based options are often cheaper than plant-based options on the menu. The City of Vancouver spends an estimated $750,000 on catering for meetings and events annually and although this may be low relative to other organizations' spending on food, the City's catering policy is expected to have a significant impact on municipal food-related GHG emissions.

Quantitative assessment of GHG estimates

The GHG estimation presented in this section accounts for about 80% of food and beverage items procured by the services considered- three low cost meal providers and Vancouver Parks Board- and make up a majority of food procured by the City of Vancouver. The food items excluded from the GHG estimation framework include soft drinks, spices, herbs, and processed or packaged foods without a key identifiable ingredient (including dressings, sauces, prepared meals etc). Procurement from these streams, excluding aforementioned food items and emissions associated with processing, consumption and waste, accounted for about 1100 tonnes of Scope 3 GHG emissions in 2018. Although this is small compared to currently accounted total GHGs (Scope 1 and 2) from Vancouver (2,440,000 tonnes of GHG in 2018), changes in municipal procurement policy would demonstrate leadership in dietary transitions and could influence residential consumption patterns.

Figure 3 outlines the share of GHG emissions from each food procurement stream by food group. As shown, beef and pork account for about 71% of total GHG emissions from food procured, the largest share by any food group. This is followed by vegetables (9%), dairy (7%) and poultry (6%). There are significant differences among the services – the share of beef and pork-related GHG emissions ranges from 44% to 78%.

Similarly, the share of dairy-related emissions shows a wide range – from 4% to 21%- across food providers. In the absence of quantitative data on other municipal food procurement such as catering, which has a majority of meat-based items on menus, these results point towards dietary shifts towards sustainable diets that can be made across institutional food provision.

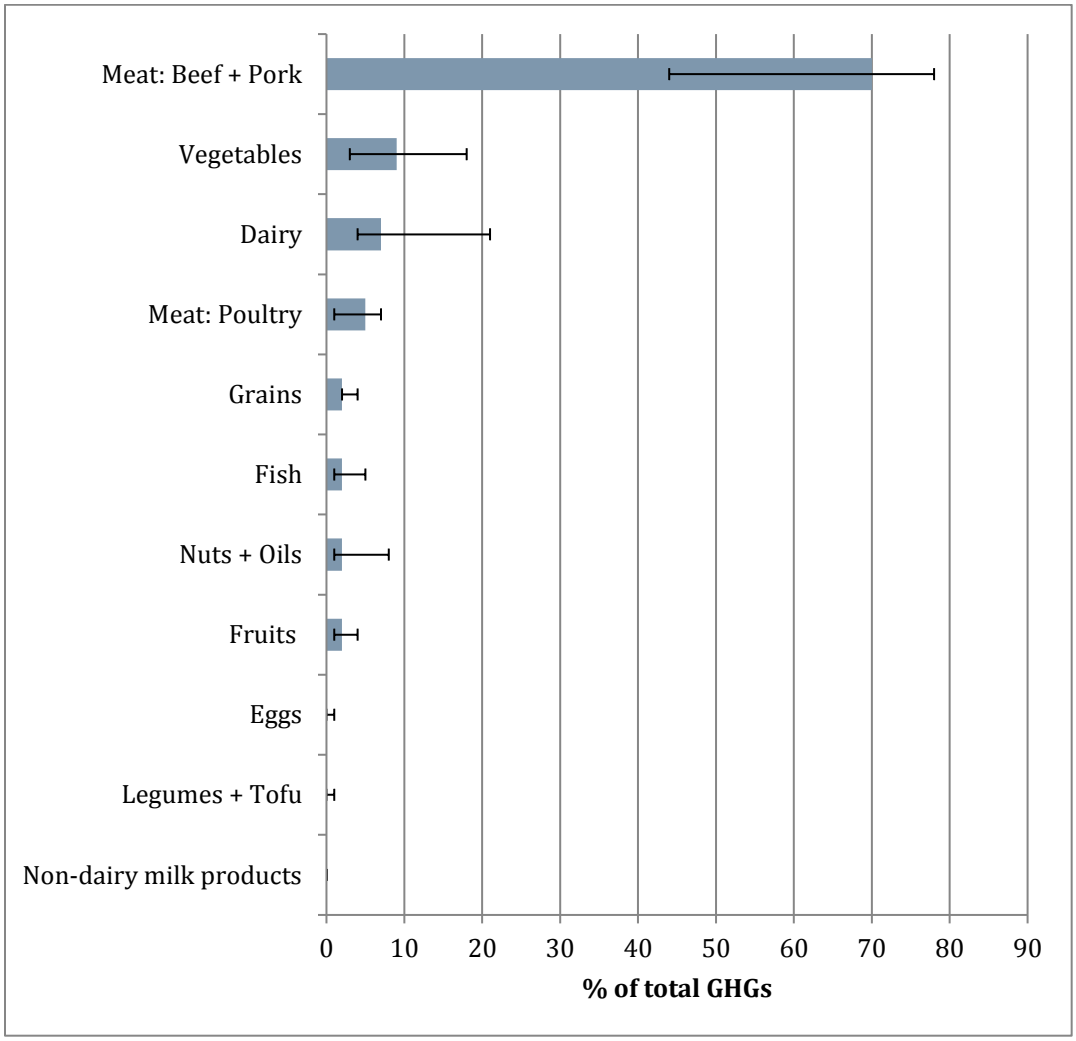

Figure 3 Share of greenhouse gas emissions by food group in the City's total municipal food procurement (error bars represent maximum and minimum values across procurement streams)

Scenario analysis

Substituting all beef and pork with legumes

This substitution would reduce total GHG emissions by 69%, even though legumes are imported and have transport-related GHG emissions associated with them. The GHG reduction impact varies between 60% and 77% across food providers considered in this analysis. Emission factors (emissions per unit kilogram of food) for local and imported meat are similar and there is no local GHG advantage to switching from imported meat items to local meat. Given the high proportion of meat-based items on catering menus, we expect a similar emission reduction impact of dietary shifts in catering from beef and pork to legumes.

Substituting all beef and pork with chicken

This leads to 55% reduction in total GHG emissions from the services considered. Thus, even without transitioning from high GHG intensity meats like beef and pork to a plant-based protein source, significant emission reduction can be achieved by transitioning to a low carbon meat.

Meatless Monday

A Meatless Monday scenario, in which beef, pork and poultry consumption is reduced by one-seventh to simulate serving meatless meals one day in a week in municipal food services, leads to 11% reduction in total GHG emissions. The reductions are cumulative, i.e. the more days that meatless meals are served, the higher the reduction in GHG emissions.

Substituting all dairy with legumes

Substituting all dairy products with plant-based protein such as legumes leads to 5.5% reduction in GHG emissions. Although dairy products are GHG-intensive, the quantities purchased by the municipal food providers are generally small and do not significantly impact GHG emissions.

Transitioning from imported fruits and vegetables to locally grown fruits and vegetables (where possible)

This reduces total GHG emissions by 7%, with the effect being particularly pronounced for the vegetable group since a large portion of the vegetables consumed can be grown in BC, as opposed to the types of fruit consumed such as oranges which cannot be grown in BC on a commercial scale. Thus promoting the local food economy by encouraging vendors to procure local food has a GHG advantage for the vegetable group in particular, reducing 60% of GHG emissions associated specifically with the vegetable group. This is significant as vegetables are the second largest GHG emitting food group in the procurement considered.

Reducing total meat and dairy consumption to meet EAT-LANCET daily dietary guidelines by weight

Reducing meat and dairy consumption to meet EAT LANCET daily dietary guidelines reduces GHG emissions by 35% to 75%. Thus a transition towards healthier diets as outlined by EAT LANCET has the advantage of global environmental benefit.

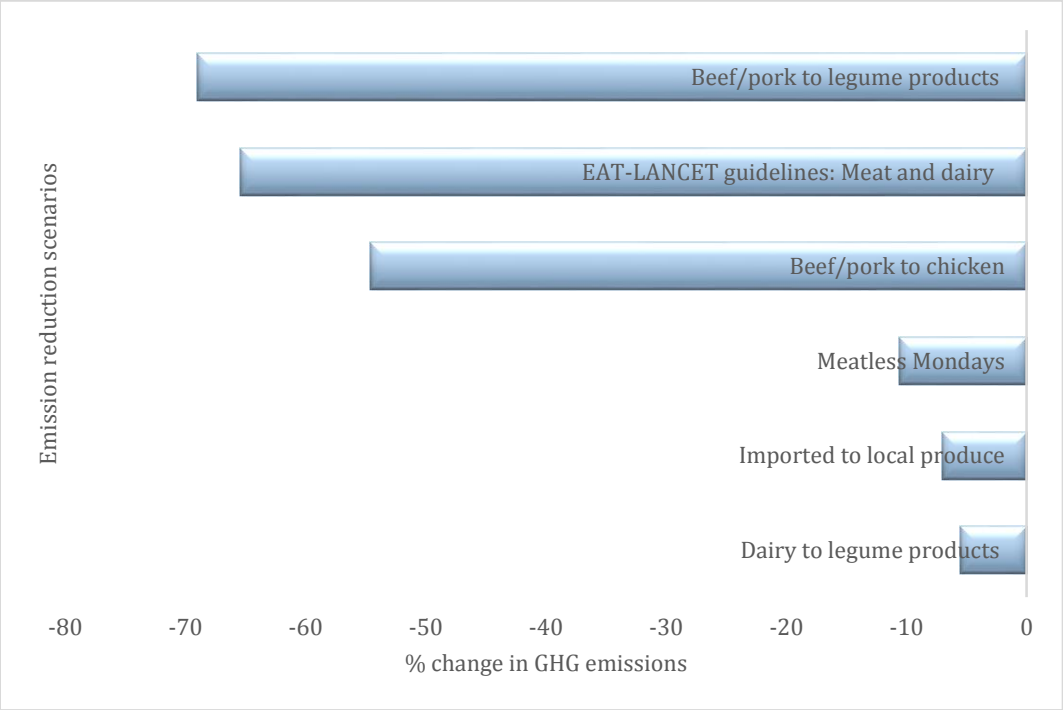

Figure 4 Estimated GHG emission reductions for low carbon scenarios

Recommendations for policy priorities

1. *Dietary transitions:* This analysis, consistent with previous studies in this sector, indicates that the GHG emission reduction strategy that could have the highest impact is reducing meat consumption, particularly beef and pork, and transitioning towards low-carbon options such as legumes. This transition in municipal food procurement would require partnership with the different food providers such as the low cost meal providers, golf courses, community centres, concession stands, theatres and catering, to understand the dietary preferences of their clients and their willingness towards the transition. We recognize that dietary transitions may look different for different types of food procurement, for example implementing Meatless Mondays may work in a particular service but not in another, and that any decision must be considered within an equity lens. The scale of operations is another aspect to consider when formulating dietary transition policies – for example, this work could inform City of Vancouver's catering policy where it could be logistically easier to implement changes in types of food procured for City events, compared to large scale operations. Suggestions for incremental implementation of dietary changes include:

    a) Pilot studies on the demand for/uptake of plant-based meal options within each municipal food service. For example, open houses and events within a group on low-carbon catering options to assess feasibility of dietary transitions, or increase in plant-based options and their visibility on menus for a specific period of time. The results of the pilot study could inform policies such as the next Green Operations Plan or catering policy across the City.
    b) Substituting high carbon meat options such as beef and pork with low-carbon meat options such as chicken in catering and other food provision.
    c) Ensuring a meatless/plant-based option is available on all menus and introducing a "Meatless Monday" program wherein meat options are not available on certain day(s) of the week.

2. *Local Food:* A transition from imported fruits and vegetables to local equivalents (in cases where the food item can be grown locally) has a far lesser impact (7% reduction overall) on GHG reduction compared to shifts from meat to plant-based meals. However, a thriving local food economy can provide other crucial advantages such as ensuring food security. There is a clear local advantage in terms of GHG emissions specifically for the vegetables procured by municipal services and this effect may become more significant if food services increase the proportion of vegetables served in meals and concurrently

reduce meat and dairy. There is a lesser emission reduction opportunity in switching from imported to local cereal products as much of it cannot be grown locally.

3. *Greenhouse produce:* The literature on food system GHG emissions indicates that greenhouse produce is 3-10 times more GHG-intensive than field grown produce, depending on the region of production. Particularly in cold climates, where greenhouses require more heating, it might be worth considering importing field-grown produce. However, an analysis of the impacts of substituting greenhouse produce with imported field grown produce was beyond the scope of this project due to limitations on data available on mode and location of production. Another suggested next step is exploring if field and greenhouse grown produce can be identified on City of Vancouver food order sheets.

Opportunities for future projects

This work is based on food procurement data available from the City – namely, three low cost meal providers and Vancouver Parks Board - and sheds light on the GHG intensity of food items procured by these agencies. For the purpose of a comprehensive baseline estimate of GHG emissions from municipal food procurement (particularly if GHG accounting for food services is a component of future climate action plans), a common accounting framework and a liaison officer for coordinating data collection from a range of disaggregated services such as catering and Vancouver Civic Theatres is needed.

The estimates in this work are based on a number of assumptions – for example, region of import of food items, mode of transport and methods of production – either directly made in this study or those made in previous studies that inform this analysis. For a precise and more refined estimation of GHG emissions, more detailed data accounting is needed. Existing data gaps include location of production and mode of production (greenhouse produce, organically grown meat, trawler fishing, farmed fish etc), both of which are key variables for estimating GHG emissions.

Future projects could also incorporate GHG emissions from other stages in the food system cycle such as processing, packaging and food waste. Given the emphasis on food waste action in other municipalities and the significant role it can play in reducing embodied food-related GHG emissions as stated in literature, data needs to be collected on the quantity of procured food that is wasted, at the distributor/vendor level and post-consumer plate waste. This could inform City of Vancouver's municipal food waste policy, which could include collaborating with food vendors that work towards minimising waste, as a way of demonstrating leadership in the area.

Estimating GHG emissions associated with processing different foods, for example, milling of flour, canning different foods, baking items like bread, processing meat into burgers, etc. and packaging food items was beyond the scope of this project. There is also high uncertainty in emission factors specific to species of fish imported from different regions and through different modes of operation of fisheries (i.e., farmed or wild and trawler fished etc). Further work on this project could include a deeper and detailed dive into the literature on emissions from processing and packaging food items and different species of fish imported in Vancouver.

Concluding thoughts

The reviewed literature on GHG emissions from food systems points towards a transition from meat to plant-based diets as the most impactful strategy to reduce emissions. The report by the *EAT*-LANCET Commission (2019), addressing the challenge of providing a growing population with healthy diets that are concurrently environmentally sustainable, strongly indicates that plant based diets are healthier options than meat-based diets for individuals as well as our planet. The food procurement data available from two agencies within the City of Vancouver – low cost meal providers and Vancouver Parks Board- shows that the City's food services could be optimized for personal and planetary health by implementing the recommendations on dietary shifts made through this study. Given that more than half of a Vancouver resident's ecological footprint is due to food consumption, taking action to reduce the City's own food-related GHG footprint would demonstrate leadership to the community and could be a way of affecting dietary changes among residents.

This study recognises that a transition from current diets towards plant-based ones needs dialogues about equity, food choices and access, sensitivity towards cultural practices and strong partnerships with relevant stakeholders, both food providers and clients. Additionally, while certain food policy strategies such as promoting the local food economy may not provide significant GHG reduction benefits, this report focusses solely on the GHG emissions impact of food and acknowledges that the benefits of local food in terms of other indicators of food system well-being such as local food security have not been considered and were out of scope for this project.

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