
Diets
for a
Cool
Planet:
Healthy, Sustainable Diets for Toronto
TORONTO Public Health

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## Executive Summary

There is a dynamic relationship between food and climate change. Climate change impacts food production and sustainability, while the way food is produced, how it is transported, the type of food that is eaten and the amount that is wasted can have significant impacts on climate change. Evidence suggests that one of the quickest ways to mitigate climate change is by shifting to more environmentally sustainable diets. Shifting to more sustainable diets would be beneficial for health as it involves increased intake of healthy, affordable foods that are currently underconsumed and decreased intake of foods that are currently overconsumed.

Emissions of greenhouse gases (for example, carbon dioxide, methane and nitrous oxide) are causing significant changes in the global climate. The climatic changes that are occurring, including warmer temperatures and increases in the intensity and frequency of severe weather events, will impact the global food system by affecting crop yields, livestock productivity, the nutritional content of some foods and food safety and security. Ontario will likely have a longer growing season, warmer weather with more frost free days, and increased precipitation. While these factors could be an opportunity to increase crop yields, the negative impacts of climate change could outweigh any benefits. The warmer weather is expected to increase evaporation from soil and plants and increase heat stress experienced by livestock. In addition to heat and water stress, increases in extreme weather events and more pests, invasive species and diseases may have an overall negative impact on food production in Ontario.

At the same time, the global food system directly contributes to climate change and environmental degradation. Global population growth (almost 10 billion by 2050), increased urbanization, and rising incomes are driving unsustainable increases in resource-intensive agricultural production. Looking across the food system, the production stage contributes the most greenhouse gas emissions, with animal-based foods having higher greenhouse gas emissions than plant-based foods, especially red meat and dairy products. Food waste is often the second highest contributor to greenhouse emissions with one third of all food produced being lost along the supply chain or wasted after purchase.

While there are opportunities to reduce greenhouse gas emissions through technological changes in production, modelling of potential scenarios suggests that changes in dietary patterns would have more impact on reducing emissions. Specifically, reducing meat intake, especially red meat, and increasing intake of plant-based foods (vegetables, tubers, pulses, legumes, whole grains, nuts, seeds, and fruits) would be beneficial. While some have called for a switch to vegetarian or vegan diets, eliminating meat is not necessary to make a difference in one's carbon footprint – lowering meat intake can achieve a large reduction in diet-related greenhouse gas emissions.

Lowering meat intake and increasing intake of plant-based foods would be beneficial for the health of many people in Toronto. Canadians eat more meat and fewer vegetables and fruits than is recommended for health. While meat is a convenient way to access certain nutrients (iron, B vitamins, and zinc) and all amino acids, it tends to be high in saturated fat and does not contain fibre. Plant-based foods are health protective in many ways and plant-based proteins,

including pulses, legumes, nuts, and seeds, are good sources of magnesium, fibre, and unsaturated fats.

The promotion of healthy, sustainable diets needs to be culturally-appropriate and take into consideration the many factors that influence what foods people consume, including socioeconomic and sociocultural factors. It is important to note that some of the most sustainable foods with the lowest climate impacts are also nutritious and inexpensive. Meat intake is an important part of many cultures and can be associated with social status. However, many people are not aware of the impact that meat has on environmental sustainability. Increasing awareness and targeting certain social norms, while respecting cultural, religious and Indigenous traditions, provides an opportunity to equitably shift towards more healthy and sustainable diets.

Overall, shifting towards more sustainable diets is an opportunity for achieving multiple aligned public health goals in Toronto. Increasing the consumption of plant-based foods while reducing meat, as appropriate, is an affordable approach to improving nutrition. While many climate-friendly foods are beneficial for human health, it is important to note that the goal is not necessarily to move towards diets with the lowest emissions possible, but instead to aim for diets that are nutritious, culturally appropriate, sustainable and with lower greenhouse gas emissions. Increasing awareness of the impact that dietary patterns have on climate change can promote a shift to healthy and sustainable diets among people in Toronto.

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## Glossary

Acidification: increasing the acidity of soils and water bodies (Merriam-Webster)

Carbon footprint: the amount of greenhouse gases and specifically carbon dioxide released into the atmosphere as a result of the activities of a process, system, individual, organization or community (adapted from Merriam-Webster and Oxford Living Dictionaries)

Climate-friendly: does not cause any damage which will change the Earth's weather patterns (Cambridge Dictionary)

Eutrophication: the process by which a body of water becomes enriched in dissolved nutrients (such as phosphates) that stimulate the growth of aquatic plant life usually resulting in the depletion of dissolved oxygen (Merriam-Webster)

Greenhouse gas (GHG): any of various gaseous compounds (such as carbon dioxide, methane, and nitrous oxide) that absorb infrared radiation, trap heat in the atmosphere, and contribute to the greenhouse effect (Merriam-Webster)

Low-carbon: causing or resulting in only a relatively small net release of greenhouse gases into the atmosphere (adapted from Oxford Living Dictionaries)

Omnivorous: feeding on both animal and plant foods (adapted from Merriam-Webster)

## Acronyms

AAFC: Agriculture and Agri-Food Canada

FAO: Food and Agriculture Organization

FCRN: Food Climate Research Network

IOM: Institute of Medicine

OMAFRA: Ontario Ministry of Agriculture, Food and Rural Affairs

UNEP: United Nations Environmental Program

# 1 The relationship between the food we eat and climate change

Food, climate change and health are linked across the food system. Climate change impacts food production and sustainability, while food choices, production, consumption and waste can have significant impacts on climate change. Over the past 60 years, food production has become more industrial, intensive and global. While these changes have brought many benefits such as increased food production, efficiency and improved food safety, the food system is a significant contributor to greenhouse gas (GHG) emissions, biodiversity loss and environmental degradation. In addition, the 'triple burden of malnutrition' – undernutrition, micronutrient deficiencies, and overweight and obesity – remains a global health problem affecting most countries. Without significant changes in our approach to food and agriculture, environmental sustainability and food security challenges will continue to worsen as climate change occurs and world population increases to almost 10 billion by 2050 (FAO, 2017).

This report provides an overview of the links between climate and food, and the contribution of healthy sustainable diets to lowering GHG emissions from the food system. It considers health, equity and environmental sustainability in addition to reducing the carbon footprint of diets. The promotion of sustainable diets needs to include respect for cultural, religious, and Indigenous traditions. Many cultures and religions adhere to specific diets and many value consuming specific types of foods. The evidence suggests that a diet that is good for health can be good for the environment, and that healthy, sustainable diets can reduce costs of food.

**Impact of Climate Change on the Food System**

Increasing GHGs in the atmosphere are expected to result in higher temperatures, changes in precipitation and more frequent and severe extreme weather events (IPCC, 2014). These changes pose a significant risk to local and global food security and will further affect our ability to distribute resources equitably (IPCC, 2014; Myers et al., 2017; Schmidhuber & Tubiello, 2007). When considering the impact of climate change on the food system, it is important to consider both the local and global context. As the food system is globalized, climate change impacts in other parts of the world can affect Toronto.

Crop yields and livestock are likely to be significantly impacted by climate change. In Ontario, and other temperate regions, climate change may have some benefits for food production (Schmidhuber & Tubiello, 2007; IPCC, 2014). Ontario will likely have a longer growing season (three to five weeks), warmer weather with more frost free days and increased precipitation (Motha & Baier, 2005; AAFC, 2015; OMAFRA, 2016a). These factors could be an opportunity to increase crop yields. However, warmer weather is expected to increase evaporation from soil and plants and increase heat stress experienced by livestock. In addition, increases in extreme weather events and more pests, invasive species and diseases may have an overall negative impact on food production.

The potential increase in pests and invasive species is an aspect of one of the major impacts occurring with climate change: Significant shifts are occurring in the range, seasonal activities, migration, abundance and interactions of many land and water species (IPCC, 2014). Changes in

the distribution of any one species can have ripple effects across entire ecosystems (Pecl, G.T. et al., 2017). These changes will effect certain regions more than others – for example, fish, reindeer and caribou distribution changes are already affecting traditional food and knowledge systems in northern regions (e.g. the Arctic, East Siberian tundra). In addition, changes in biodiversity also impact climate change in all regions by changing how much carbon is stored on land and in the ocean.

Evidence suggests that elevated carbon dioxide ($CO_2$) levels could affect the nutritional content of certain foods (Loladze, 2002). In particular, higher carbon dioxide ($CO_2$) levels might be decreasing the zinc and iron content of cereal grains and legumes (Myers et al., 2014) and the protein content of rice, wheat, barley and potatoes (Medek, Schwartz, & Myers, 2017; Myers et al., 2014). Populous regions that are dependent on these food staples may be most affected (Medek et al., 2017). In addition, countries already experiencing high rates of undernutrition will likely be further disadvantaged due to these declines in the nutritional content of food staples.

Climate change may also have an impact on food safety due to changes in food and water-borne diseases, as well as an increase in the number of food poisonings (Schmidhuber & Tubiello, 2007). Populations facing high rates of infectious disease(s) may be more susceptible to undernutrition which in turn can increase the rates of infectious disease. Both disease and undernutrition can effect labour productivity, poverty and mortality.

Figure 1 illustrates how releases in greenhouse gases affect the quality and quantity of food produced through changes in biophysical resources (soil health, water availability, sunlight, $CO_2$, temperature, pollination), extreme weather events, the concentration of ground-level ozone, pests, pathogens and pollution, as well as socio-economic factors such as changes in human productivity due to extreme temperatures (Myers et al., 2017).

**Contribution of the Food System to Climate Change**

While climate change is a threat to food security, the food and agriculture sector also contributes significantly to GHG emissions, biodiversity loss and the degradation of land, soil, and freshwater and marine environments (Johnson, Runge, Senauer, Foley, & Polasky, 2014; Smith et al., 2014; UNEP, 2012; FAO, 2017). This report focuses specifically on GHG emissions. However, focusing on GHG emissions to mitigate climate change will likely also have co-benefits for other important aspects of environmental sustainability such as land use, energy use, acidification and eutrophication. For example, deforestation to create more land for livestock pasture or feed crops has significant impacts on biodiversity and releases substantial amounts of carbon dioxide into the atmosphere (UNEP, 2012; FCRN, n.d.).

**Figure 1: Pathways for impacts of climate change on the global food system, food security, and undernutrition (Adapted from Myers et al., 2017)**

| | |
|---|---|
| **Human Activity** | • Greenhouse gas (GHG) emissions<br>• Other environmental impacts |
| ⬇ | |
| **Climate and atmospheric shifts** | • Temperature increase<br>• Rainfall variability<br>• Extreme weather events<br>• Increased atmospheric $CO_2$ and ozone levels<br>• Ocean temperature increase<br>• Ocean acidification |
| ⬇ | |
| **Proximate biological consequences** | • Increased exposure to enteric pathogens<br>• Greater pest, pathogen, weed pressures<br>• Pollinator declines<br>• Animal heat stress<br>• Changes in forage species composition and productivity<br>• Altered primary production, poleward shifts of species, smaller mean fish size<br>• Effects on crop yields<br>• Poorer crop nutrient content<br>• Altered fish nutrient content<br>• Coral reef degradation and shellfish declines<br>• Lower human labour capacity<br>• Greater postharvest losses |
| ⬇ | |
| **Impact on human socioeconomic systems** | • Higher frequency of international conflict<br>• Lower economic growth<br>• Lower purchasing power of nutritionally vulnerable populations<br>• Altered crop yields and reduced nutrient content<br>• Price increases and volatility<br>• Altered livestock productivity<br>• Altered fish catch and nutrient content |
| ⬇ | |
| **Nutritional and health consequences** | • Increase in diarrheal diseases and enteric infections<br>• Altered global nutrient supply<br>• Altered nutritional status |

Taking into account energy used, the Food and Agriculture Organization (FAO) estimates that the food and agriculture sector contributes to about 25% of the world's GHG emissions (FAO, 2011 as cited in FAO, 2017). Estimates of the contribution of agriculture to overall GHG emissions in Canada exclude emissions from fossil fuel use or fertilizer production. Agriculture contributes 10% of GHG emissions in Canada (AAFC, 2016) and 5% in Ontario (OMAFRA, 2016a). The reasons agriculture in Canada contributes a smaller proportion of total emissions is likely the result of several factors. The relatively cold climate, sparse population relative to land mass and high international demand for natural resources in Canada results in a higher proportion of energy and transportation emissions in Canada compared to other industrialized nations (Environment and Climate Change Canada, 2017). As well, since the food system is globalized, the emissions related to feed and food imports are not included in Canada's total contribution. Ontario is a net importer of fruits, nuts, vegetables, red meat, poultry, eggs and dairy products (Econometric et al., 2015).

Life-cycle assessments (LCA) studies show that food production specifically contributes the largest proportion of the food system's total GHG emissions, about 80% (Smith et al., 2014; Johnson et al., 2014; Weber & Matthews, 2008). It is usually responsible for much higher emissions than the food transportation stage, which contributes about 11% of GHG emissions. There are opportunities for climate change mitigation on both the supply-side (land use and management, livestock management, carbon sequestration in soils, energy production, sustainable intensification) and the demand-side (reducing food waste and losses, consumption patterns) of agricultural production (Smith et al., 2014). However, scenario modelling suggests that changes in consumption would have more impact on reducing GHG emissions than technological changes on the supply-side. Changes in diets could result in 34% - 72% reduction in GHG emissions whereas technological changes could result in a 13% - 22% reduction (Smith et al., 2014).

Dietary patterns directly affect the GHG emissions of food production by influencing how much food and what type of food is produced (Fischer, & Garnett, 2016; UNEP, 2012). The combination of population growth, increased urbanization and rising incomes is directly driving unsustainable increases in resource-intensive agriculture production (UNEP, 2012). Urbanization provides access to a more diverse, nutrient-dense diet even for people with relatively low incomes. Except for vegetarians, increased affluence is associated globally with increased consumption of animal products. This trend is gradually reversing in developed countries with higher socio-economic groups consuming less red and processed meat; it is estimated that individuals need an average income of US$ 49,848 before the increase in meat consumption starts to reverse (Cole & McCoskey, 2016).[1] As the amount of natural resources and arable land on the planet is limited, changes in dietary patterns are needed to influence the sustainability of food production (UNEP, 2012; Gerber et al., 2013). Changing demand by shifting to more sustainable diets will induce a shift to less resource intensive and lower-carbon food production.

[1] This is above Toronto's median 2015 individual income of CA$ 33,456 for men and CA$ 27,576 for women (Statistics Canada, 2017).

**Carbon footprint of different types of food**

When examining the GHG emissions of agriculture, life cycle assessments indicate that the type of food produced or consumed is more important than how or where production takes place. Animal-based foods typically have higher GHG emissions than plant-based foods (Carlsson-Kanyama & González, 2009; Pathak et al., 2010; Bellarby et al., 2012; Berners-Lee et al., 2012; Smith et al., 2014). Exceptions to this are greenhouse-produced (heated) and air-shipped produce (Carlsson-Kanyama & González, 2009; Smith et al., 2014).

**Box 1: GHG Emissions and Local Food**

From a GHG emissions perspective alone, when choosing local food it is helpful to consider the type of food grown, seasonality and production methods. As food transportation only accounts for 11% of the total emissions in the food lifecycle, local food can make a difference in GHG emissions if the food is in-season and grown with low energy inputs (e.g. field-grown), but might have higher GHG emissions if the food is more suitably grown elsewhere (MacRae, 2013). For example, it can be less GHG-intensive to transport tropical and sub-tropical fruit and vegetables by ship from warmer climates. Air-freighted food produces high GHG emissions, but accounts for just 1-2% of food trade in North America.

From a holistic food system perspective, local food can have economic, environmental and social benefits for communities. Ontario's Local Food Strategy is focused on creating new jobs and expanding the local agri-food sector in Ontario (OMAFRA, 2016b). These benefits are important considerations for community and food system resiliency, and thus buying local food can support these goals.

The Food Strategy led by Toronto Public Health promotes a healthy sustainable food system and facilitates a number of initiatives to reduce food waste, promote local production, and healthy food access.

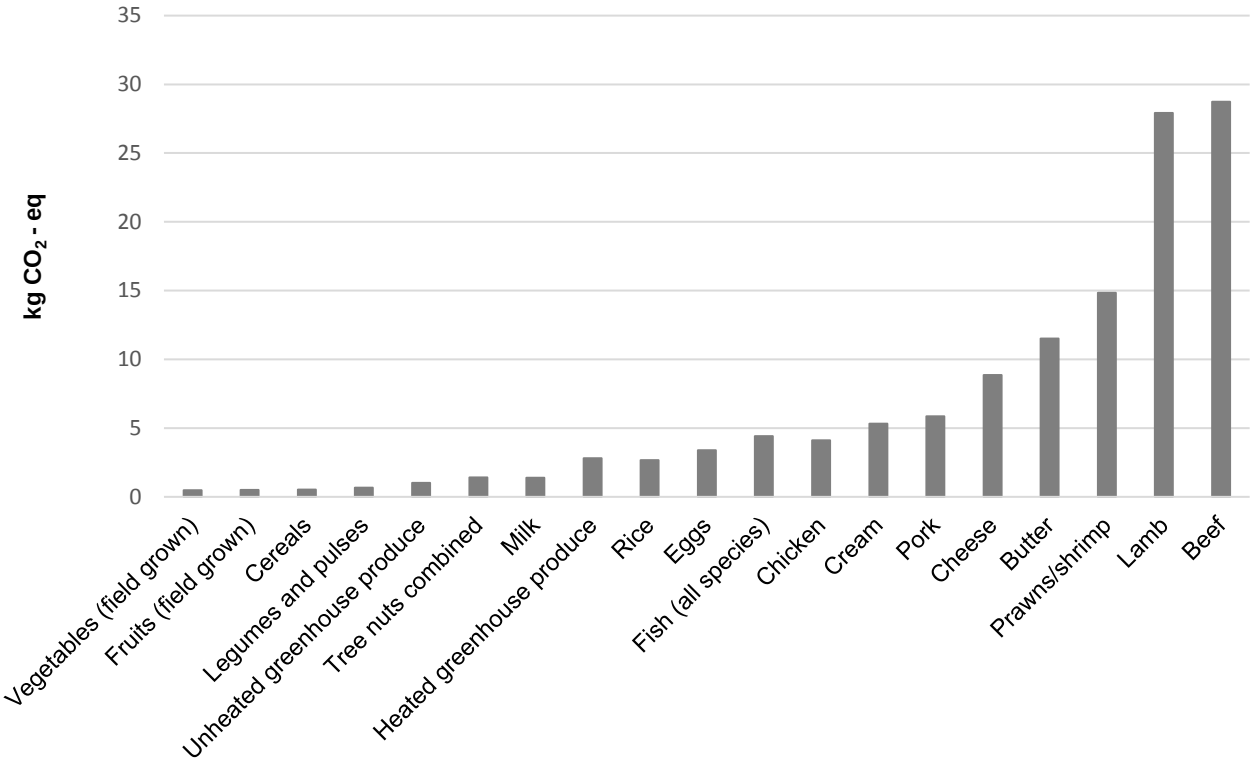
**Box 2: GHG Emissions and Organic Production**

Many researchers and organizations indicate that organic systems have higher GHG emissions than modern systems. Organic systems have been found to have lower yields, require more land and are less resource efficient than high-input systems (Bradgley & Perfecto, 2007; Seufert, Ramankutty & Foley, 2012). However, in a recent review, Clark & Tilman (2017) concluded that the differences are small. The environmental benefits of organic approaches offset the benefits associated with the high yields of modern approaches.

Organic production systems contribute to sustainable agriculture by maintaining long-term soil health, promoting biodiversity, decreasing pollution and recycling materials and resources (OMAFRA, 2016c). Organic methods can be beneficial for the health of agricultural ecosystems. Clark and Tilman (2017) suggested that incorporating organic practices into modern intensive agriculture would combine the benefits of organic and conventional systems.

Clark and Tilman (2017) conducted a meta-analysis of the life cycle assessments of 742 food production systems, mostly high-input systems in Europe and North America (reflective of impacts of the predominant systems in developed nations). The authors analyzed GHG emissions, land use, energy use, acidification potential and eutrophication potential and found that "…for all indicators examined, ruminant meat (beef, goat and lamb/mutton) had impacts 20-100 times those of plants while milk, eggs, pork, poultry, and seafood had impacts 2-25 times higher than plants per kilocalorie of food produced" (p.8). The findings that ruminant meat has the highest impact and other animal-based foods have intermediate impacts remains whether foods are examined per gram of protein, USDA serving, or weight. This is illustrated in Figure 2.

**Figure 2: Average greenhouse gas emissions for selected foods (in kg of $CO_2$-equivalents) by kg of edible weight of food (data from Clune et al., 2017).**

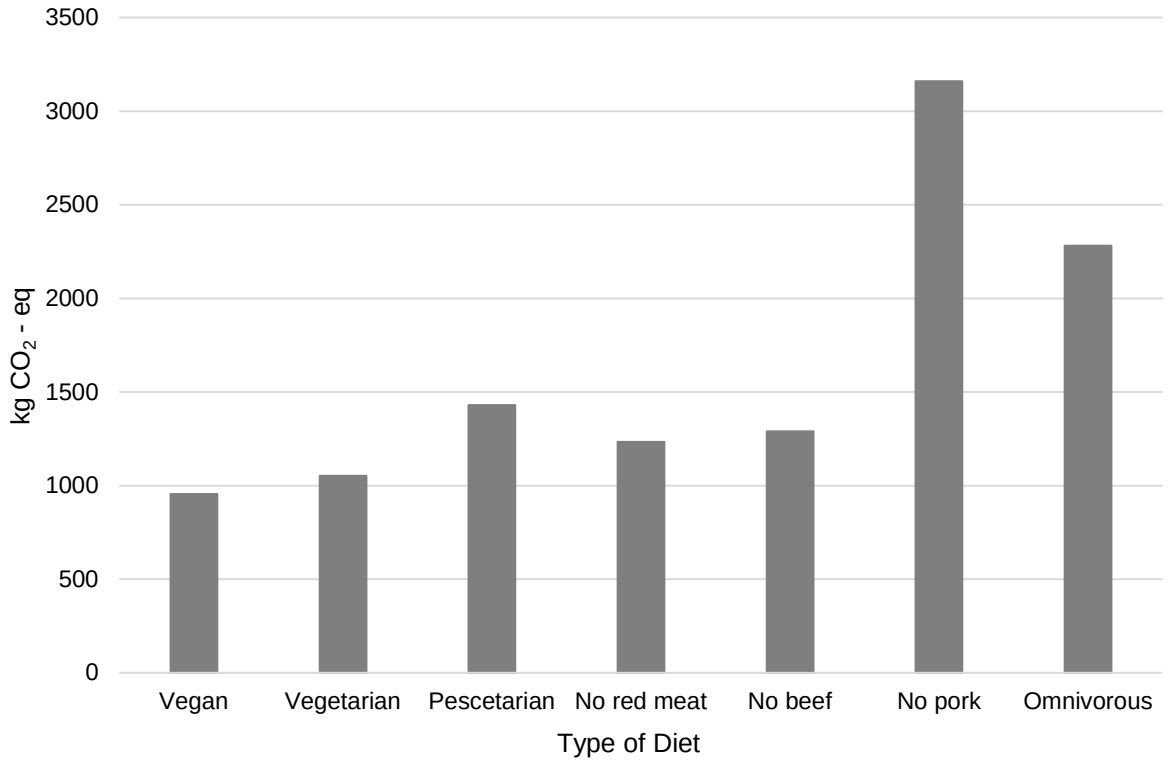



The high GHG emissions of ruminant livestock (cows, goats, and sheep) is due to a few interacting factors. These animals directly produce methane through enteric fermentation during their digestion of food (Gerber et al., 2013). Non-ruminant, farm-raised animals (pigs, horses, chickens) produce much less methane. In addition to these emissions, meat production is an inefficient way to for humans to obtain calories compared to obtaining them directly from plants, and is much more resource-intensive (water, land, energy) (Cassidy et al., 2013). Meat, especially beef, is the primary cause of deforestation, and the highest water and land user (FCRN, 2017).

**Carbon footprint of different diets**

To estimate the environmental impact of overall dietary patterns in Ontario, Veeramani et al. (2017) used a life cycle approach to complete a preliminary examination of the dietary patterns of 10,723 Ontario residents. The "No Pork" and "Omnivorous" diets were associated with the highest carbon footprint due to the high consumption of meat, particularly beef. Diets with the lowest GHG emissions were vegan and vegetarian diets; these had about 55% fewer GHG emissions than omnivore diets. Excluding beef or red meats from the diet reduced GHG emissions by approximately 45% as compared to omnivore diets, and diets that include fish (but no meat) have about 40% lower emissions than omnivore diets (See Figure 3).

**Figure 3: Estimated carbon footprint of Ontario food baskets on a farm-to-table basis (adapted from Veeramani et al., 2017)**

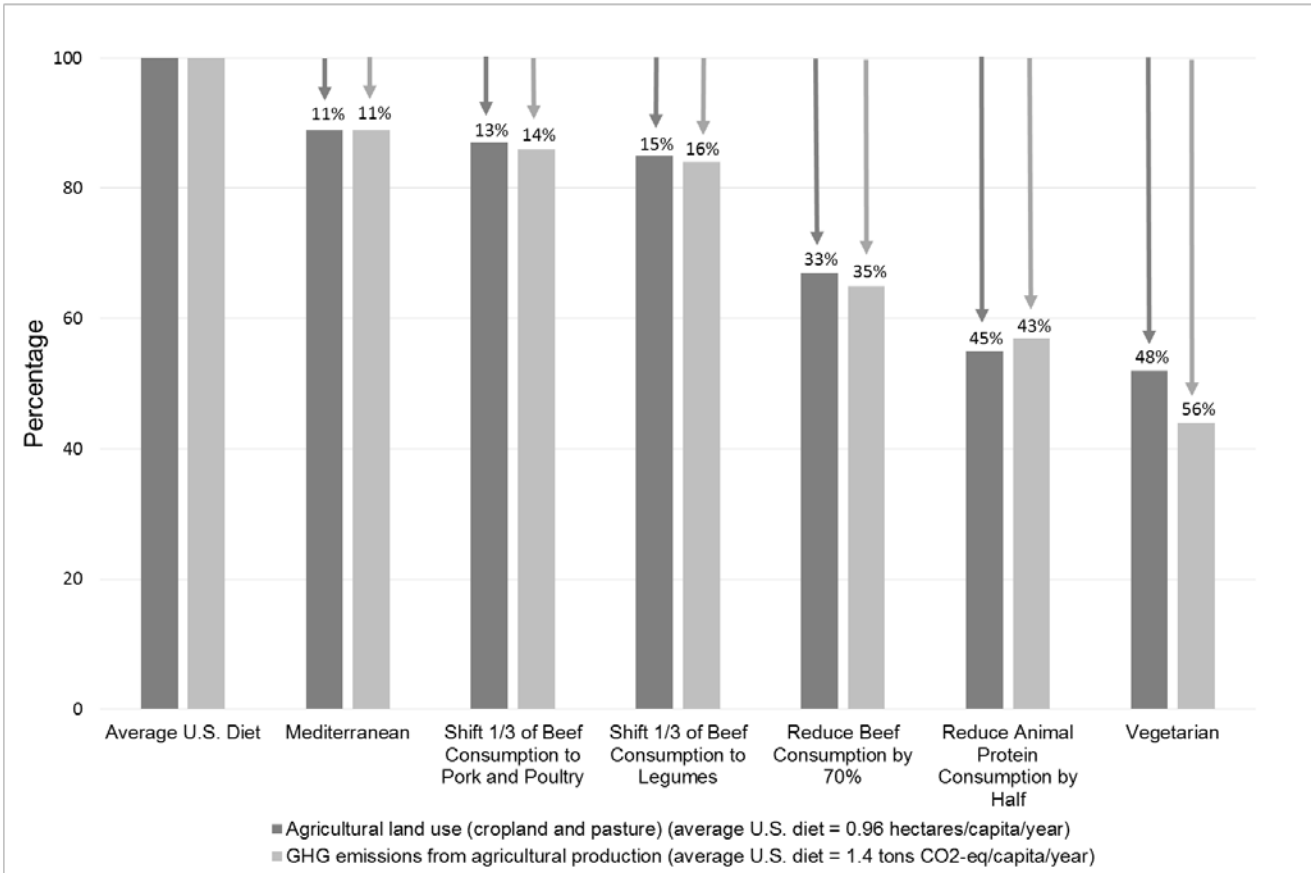



The estimates of the carbon footprints of individual food types as well as type of diet indicate that reducing consumption of high-carbon foods, particularly red meat, would be beneficial for reducing GHG emissions. It has been estimated that 20 - 30% of GHG emissions from food production could be reduced through shifting typical Western diets to more sustainable diets (Aleksandrowicz et al., 2016). This is illustrated in Figure 4, which shows the impact of shifting current US diets to ones that contain less meat – low-meat diets can be low-carbon.

## 2 Characteristics of Healthy Diets

Health Canada's Eating Well with Canada's Food Guide and the Eat Well Plate are used by Toronto Public Health and others as a nutrition resource to guide healthy eating recommendations. Healthy diets emphasize high consumption of vegetables, fruit, whole grains and protein-rich foods, especially plant-based sources of protein; moderate amounts of unsaturated fats and oils; and limited consumption of processed foods and beverages that are high in sodium, sugar and saturated fat (as proposed for updated Canada's Food Guide). As such, a diet that emphasizes foods that have a low carbon footprint can also be healthy.

**Figure 4: Projected environmental benefits of shifts in dietary patterns in the U.S. (adapted from World Resources Institute, 2016)**




## 3 Current Diets

Available information on food consumption in Canada and Toronto indicate that current dietary patterns are neither healthy nor sustainable (see Box 4). Toronto residents do not eat enough vegetables and fruit (Toronto Public Health, 2017) and a majority of people in Ontario have low intakes of fibre, calcium, magnesium and vitamin A, while consuming too much energy and sodium (Canadian Community Health Survey, 2004).

Meat intake remains high in Canada, but consumption has shifted towards more poultry and less beef and lamb (Clonan, Roberts, & Holdsworth, 2016). However, red meat still represents around half of all meat choices: 74 g of red meat per day (52 g fresh red meat and 22 g processed red meat) (Beef Information Centre and Canadian Pork Council, 2007). By gender, Canadian men eat an average of 101 g of red meat per day, while women eat 55 g (Beef Information Centre and Canadian Pork Council, 2007).

A diverse and balanced diet consisting mainly of plant foods including vegetables and fruit, whole grains, plant-based proteins (pulses, legumes, nuts and seeds), milk and alternatives, and sustainably raised fish would contribute to improved nutritional health for Toronto residents.

## 4 Healthy, sustainable, low-carbon diets

The main focus of this report is on reducing GHG emissions. Diets that are low-carbon fit within the broader concept of sustainable diets. The Food and Agriculture Organization (FAO, 2010) describes sustainable diets as "protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe, and healthy; while optimizing natural and human resources" (Burlingame & Dernini, 2012). Implicit in this definition is that sustainable diets protect the environment and promote food security for present and future generations. The climate impact of food choices are therefore an important factor of sustainable diets.

**Box 3: Current Diets**

Available information for Ontario indicates:

- Most Ontarians do not get enough fruit and vegetables for a nutritious diet: 55% eat less than 5 servings per day
- A large majority of Ontarians do not meet fibre recommendations, with only 8% meeting the adequate intake
- Most Ontarians do not meet the recommendation for calcium (62% are below); magnesium (47% are below); or vitamin A (46% are below)
- Sodium intake is very high, with 70% exceeding the upper limit
- Protein is almost universally adequate: 99.7% of Ontarians meet the recommended intake
- Across Canada, a majority of adults exceed the amount of energy they need

(Canadian Community Health Survey, 2004)

Data from 2014 show that only 41% of Toronto residents reported getting five or more servings of vegetables and fruits per day (TPH, 2017). Income levels did not have clear correlations with vegetable and fruit intake, but sex and age were factors in whether people were more likely to eat five or more vegetables and fruits per day as shown below:

| **More likely** | **Less likely** |
|---|---|
| Female (43%) | Male (36%) |
| Older adults, especially 65+ (46%) | Younger adults, especially 20-39 (36%) |

As our understanding of the various factors and their interrelations increases, the concept of sustainable diets will improve. Various organizations have outlined aspects of a diet that are beneficial for health and at the same time have low environmental impact (for example, FAO(Food and Agriculture Organization of the United Nations) and Food Climate Research Network (Fischer & Garnett, 2016)). A healthy, sustainable diet includes:

- A wide variety of foods
- A balance between food (energy) intake and needs
- High consumption of vegetables, tubers, pulses, legumes, whole grains and fruits (especially those that are field grown and are not transported by air)
- Plant-based sources of protein, and, if eaten, smaller amounts of meat and some eco-friendly fish
- Dairy products or alternatives (such as fortified milk substitutes and other foods rich in calcium and micronutrients) in moderation
- Moderate amounts of unsalted seeds and nuts
- Oils and fats with a beneficial Omega 3:6 ratio such as rapeseed and olive oil
- Very small amounts of foods high in fat, sugar or salt and low in micronutrients, for example chips, confectionary, or sugary drinks
- Tap water in preference to other beverages, particularly sugar sweetened beverages

**High consumption of vegetables, tubers, pulses, legumes, whole grains and fruits**

As previously mentioned, Canadians have lower than recommended intakes of vegetables and fruit, whole grains, and meat alternatives such as pulses and legumes. These foods contain key nutrients for optimal health. Diets characterized by high consumption of these foods, along with lower intake of red and processed meats, refined grains, and sugar sweetened foods and beverages are associated with lower risk of chronic disease (Health Canada, 2015).

**Plant-based sources of protein and, if eaten, smaller amounts of meat**

It can be difficult for individuals to ensure they have balanced diets when following vegetarian or vegan diets. Meat is a convenient way to access all essential amino acids at once; for this reason it is traditionally labelled ‘high-quality’ protein, whereas most plant proteins are missing one or more of these amino acids (exceptions are soy beans and quinoa) (Rolfes et al., 2011). Meat is also a convenient source of macro- and micronutrients, particularly of B vitamins, iron, and zinc, and not consuming meat (or no animal foods at all) makes it more difficult to meet nutritional needs, depending on access to alternative sources of these nutrients (Battaglia et al., 2015). Some populations are also more vulnerable to iron or other inadequate intake of nutrients, and many do not feel confident cooking meatless meals (Stoll-Kleeman & Schmidt, 2016).

While moderate quantities of meat can be nutritionally beneficial, on average Canadians consume more meat than they need and plant-based foods tend to be displaced from diets when meat is consumed in high quantities (Hever, 2016). The Harvard School of Public Health notes that while meat delivers all amino acids, it tends to be high in saturated fat, and has no

fibre (2016). Plant proteins, including pulses, legumes, nuts, and seeds, are good sources of magnesium, fibre, and unsaturated fats (Dietitians of Canada, 2016). Lentils, for example, are a good source of protein, are high in fibre, and contain very little fat or sodium.

Overall, the evidence indicates that it is beneficial to promote a low-meat diet; lowering meat intake and/or switching from lamb and beef to pork and chicken can reduce GHG emissions appreciably. While it is possible for diets with no intake of meat to be nutritionally adequate (McEvoy et al., 2012; Nelson et al., 2016), these diets require more planning to ensure all macro- and micronutrients are consumed.[2] At a population level, promoting a diet that is high in plant-based foods is a practical approach for ensuring nutrition needs are met while addressing environmental sustainability.

**If eaten, some eco-friendly fish**

While the health benefits of fish have been demonstrated in nutrition studies, the environmental impacts depend on the type of fish chosen. Toronto Public Health's *Guide to Eating Fish* shows 'eco-friendly' and 'eco-unfriendly' choices by species. At the same time there is concern that there are insufficient fish stock to meet global needs (Jenkins et al., 2009). In addition, climate change is predicted to shrink fish size by up to 25%, further decreasing the total amount of fish available for consumption (IoM, 2014). Most of the literature on sustainable fish recommends eating small fish that are low down on the food chain – their stocks are more resilient than those at the top and they also are more likely to be lower in environmental contaminants. Oysters, herring, sardines, and anchovies are often more sustainable than larger, carnivorous fish (IoM, 2014). Depending on harvesting practices, which can vary widely by region and species, some fish are much more climate-friendly than livestock products like beef and lamb.

**Moderate quantities of dairy products or alternatives**

The production of some dairy products can result in high GHG emissions, but these products are important sources of nutrients. Cheese, for example, is a source of protein and calcium even though it has high GHG emissions (Clune et al., 2017). Milk and yogurt are also good sources of protein and calcium while having lower GHG emissions than cheese. As such, lower fat milk/yogurt and cheeses lower in sodium and fat can be beneficial to consume in moderate amounts.

Conversely, butter and cream are not nutrient dense and have high GHG emissions. Therefore, from both a nutrition and sustainability perspective, butter and cream should only be consumed in small amounts.

[2] Many nutrition organizations have established dietary guidelines for more plant-based, vegetarian, and vegan diets (Academy of Nutrition and Dietetics, 2016).

**Box 4 – Foods of the Future**

The food industry is exploring many alternative sources of protein to meat, which can contribute to reducing GHG emissions. Novel meat products, including plant-sourced meat alternatives aim to create near-identical substitutes for meat using plants. Another approach is to grow meat in a laboratory from animal tissue, which would reduce the amount of livestock necessary (van der Weele & Tramper, 2014). These products are in early stages of development, but have promising futures in the food industry because, in addition to the nutritional or sustainability benefits, plant protein is cheaper than animal protein (Kumar, 2017).

Around 2 billion people in the world including many in Africa, Asia, and Latin America consume insects. The nutritional content of insects varies widely by species (over 1900 species are edible), age, preparation method, and environment in which they live. There are significant gaps in our knowledge of their nutritional composition and safety. From the measurements available, certain species such as crickets seem highly nutritious and very sustainable, which could make them alternatives to meat as part of a sustainable diet. Most insects eaten by humans are a complete protein source (providing all essential amino acids), high in unsaturated fats, and high in several micronutrients including copper, iron, magnesium, manganese, phosphorous, selenium, zinc, and B vitamins. (van Huis et al., 2013)

In Canada, insect nutrition is not yet part of nutrition training, but could be added for its significant potential for climate change mitigation and protection against inadequate intake of micronutrients. It is worth noting, though, that most consumers are unwilling to try eating insects (Stoll-Kleemann & Schmidt, 2016), and that it would take time to establish culinary traditions with insects in Canada.

**Very small amounts of foods high in fat, sugar or salt and low in micronutrients**

Foods low in micronutrients and high in fat, sugar or salt do not meet the criteria for healthy, sustainable diets because they are not nutrient-dense (Drewnowski et al., 2014). In addition, some inexpensive, nutrient-poor foods are made using vegetable oils that have high environmental impacts. Palm oil, for example, drives deforestation (causing carbon dioxide release), biodiversity loss, and soil erosion (Tan et al., 2009). Palm oil is primarily made up of saturated fatty acids, with almost no other nutrients (Canadian Nutrient File, 2015). Regardless of the amount of GHG emissions, some researchers also argue that decreasing nutrient-poor foods is a good way to reduce energy use in the food system because these foods may be harmful to public health (MacRae, 2013).

## 5 Factors that influence meat consumption

### Knowledge

There is a gap in the public's understanding of food and climate change/sustainability (Stoll-Kleeman & Schmidt, 2016; Jones et al., 2016). While many agree that humans are influencing climate change, when compared to other "food and sustainability" issues meat is viewed as less important than other environmental issues, such as food packaging. In addition, many people still consider meat-based diets as nutritionally better than vegetarian diets.

Despite these views, beef consumption in Canada has gradually declined since 1980 (AAFC, 2017). While people with more schooling are likely to view the production and consumption of beef as environmentally unsustainable, price appears to be the main factor influencing changes in beef consumption. The main reasons provided for lowering beef consumption include financial (62%), health and food safety (43%), environmental (24%), and ethical reasons (22%) (Charlebois et al., 2015).

### Socio-economic considerations

There is evidence of a socioeconomic gradient in meat consumption. In the U.S., lower socioeconomic groups tend to consume more red and processed meat (more often, and in greater quantities) (Clonan et al., 2016). There is an association between occupation type and intakes of red and processed meat: people working in higher management roles were found to eat less red and processed meat than those in lower technical or routine occupations. The same finding was observed for lower earning households and for people with no formal qualifications. It is informative that some of the least healthy, processed meats are being consumed disproportionately by individuals who have lower socio-economic status. Some families on low incomes may be concerned with ensuring that their children eat enough meat to provide protein and nutrients, and may choose processed meats because they are cheaper.

It is important to note that some of the most sustainable foods with the lowest climate impacts are also nutritious and inexpensive. Using U.S. MyPlate dietary recommendations Flynn & Schiff (2015) found that a plant-based healthy diet could be significantly cheaper than a healthy diet including lean meat. In healthy diets that included meat, researchers found that meat accounted for 21% of total food costs. The plant-based healthy diet cost $62 less per month (almost $750 less annually), and provided more vegetables, fruits and whole grains. The comparative chart below is based on U.S. prices and GHG impacts but is likely applicable to Canada.

**Figure 5: Protein sources by GHG impacts and food price (adapted from World Resources Institute, 2016)**

| | FOOD | IMPACT (GHG emissions per gram of protein) | COST (Retail price per gram of protein) |
|---|---|---|---|
| LOW | Wheat | | $ |
| | Corn | | $ |
| | Beans, chickpeas, lentils | | $ |
| | Rice | | $ |
| | Fish | | $$$ |
| | Soy | | $ |
| | Nuts | | $$$ |
| | Eggs | | $$ |
| | | | |
| MEDIUM | Poultry | | $$ |
| | Pork | | $$ |
| | Dairy (milk, cheese) | | $$ |
| | | | |
| HIGH | Beef | | $$$ |
| | Lamb & goat | | $$$ |

### Socio-cultural considerations

In a review of the factors influencing meat consumption, Stoll-Kleeman and Schmidt (2016) found that "cultural and religious traditions, social norms, roles and relationships and the construction of identities and lifestyles influence and shape people's behaviour towards meat" (p.1269). Religious traditions can have set rules about the consumption of animal products. In Western cultures, meat consumption can be associated with social status, affiliation with social groups, and masculinity (men are more likely to eat meat than women). As social relationships strongly influence what food people consume, the influence of social norms on eating behaviours can be a barrier but also an opportunity for encouraging high meat eaters to move towards more sustainable diets.

## 6 Conclusions

Social, cultural and economic factors influence what people eat. More widespread adoption of sustainable diets is an opportunity to achieve multiple public health goals. Moving towards diets that are more plant-based with smaller amounts of meat (if eaten) is an affordable approach to improving health and the environment, including reducing releases of greenhouse gases.

While many foods with low GHG emissions are also beneficial for human health, it is important to note that the goal is not to necessarily move towards diets with the lowest emissions possible. The goal is to aim for diets that are nutritious, culturally-appropriate, and with lower emissions. In addition, some trade-offs may be needed when choosing what food to eat, in order to balance lower emissions with broader sustainability goals (for example, promotion of organic methods and local food production).

Given that many people are not aware of the impact that meat has on the environment and many still consider meat-based diets to be nutritionally better than plant-based diets, increasing awareness of the impact that dietary patterns have on climate change could help bring a shift to more widespread adoption of healthy, sustainable diets among people in Toronto. Increasing awareness and targeting certain social norms, while respecting cultural and religious, and Indigenous traditions, provides an opportunity to equitably shift towards more healthy and sustainable diets.

## References


Agriculture and Agri-Food Canada [AAFC]. (2015, July 30). Impact of climate change on Canadian agriculture. Retrieved from http://www.agr.gc.ca/eng/science-and-innovation/agricultural-practices/agriculture-and-climate/future-outlook/impact-of-climate-change-on-canadian-agriculture/?id=1329321987305

Agriculture and Agri-Food Canada [AAFC]. (2016, August 11). Agriculture and climate – greenhouse gases. Retrieved from http://www.agr.gc.ca/eng/science-and-innovation/agricultural-practices/agriculture-and-climate/greenhouse-gases/?id=1329321969842

Agriculture and Agri-Food Canada. (2017, September 13). Per capita consumption: Protein disappearance of poultry and other animal protein sources in Canada (food available per person, per year). Retrieved from http://www.agr.gc.ca/eng/industry-markets-and-trade/statistics-and-marketinformation/by-product-sector/poultry-and-eggs/poultry-and-egg-market-information/industry-indicators/per-capita-consumption/?id=1384971854413

Aleksandrowicz, L., Green. R., Joy, E. J. M., Smith, P., & Haines, A. (2016). The impacts of dietary change on greenhouse gas emissions, land use, water use, and health: A systematic review. *PLoS One, 11*(11), 1-16.

Battaglia, E. R., Baumer, B., Conrad, B., Darioli, R., Schmid, A., & Keller, U. (2015). Health Risks Associated with Meat Consumption: A Review of Epidemiological Studies. *International Journal for Vitamin and Nutrition Research, 85*(1-2), 70 – 78.

Beef Information Centre and Canadian Pork Council. (2007, November). Red Meat Intake: A Canadian Perspective. Retrieved from http://www.cmc-cvc.com/sites/default/files/files/MeatIntake%20Fact%20Sheet%20ENG.pdf

Bellarby J., Tirado, R., Leip, A., Weiss, F., Lesschen, J. P. & Smith P. (2012). Livestock greenhouse gas emissions and mitigation potential in Europe. *Global Change Biology, 19*(1), 3-18.

Berners-Lee, M., Hoolohan, C., Cammack, H., & Hewitt, C. N. (2012). The relative greenhouse gas impacts of realistic dietary choices. *Energy Policy, 43*, 184 – 190.

Bradgley, C., & Perfecto, I. (2007). Can organic agriculture feed the world?. *Renewable Agriculture and Food Systems, 22*(2), 80-85.

Burlingame, B. & Dernini, S. (eds.). (2012). Sustainable diets and biodiversity: Directions and solutions for policy, research and action. Proceedings of the International Scientific Symposium Biodiversity and Sustainable Diets United Against Hunger, 3–5 November 2010. Food and Agriculture Organization, Rome, Italy.

Canadian Nutrient File. (2015). Protein content of milk and alternative foods. Retrieved from https://food-nutrition.canada.ca/cnf-fce/index-eng.jsp

Canadian Nutrient File. (2015). Palm kernel oil. Retrieved from https://food-nutrition.canada.ca/cnf-fce/index-eng.jsp

Carlsson-Kanyama, A., & González, A. D. (2009). Potential contributions of food consumption patterns to climate change. *The American Journal of Clinical Nutrition, 89*(5), 1704S – 1709S.

Cassidy, E. S., West, P. C., Gerber, J. S., & Foley, J. A. (2013). Redefining agricultural yields: from tonnes to people nourished per hectare. *Environmental Research Letters, 8*(3), 1-8.

Charlebois, S.; Tapon, F., von Massow, M., van Duren, E., Uys, P., Fraser, E.., … Summan, A. (2015). *Food Price Report 2016: University of Guelph Economic Brief*. The Food Institute of the University of Guelph.

Clark, M., & Tilman, D. (2017). Comparative analysis of environmental impacts of agricultural production systems, agricultural input efficiency, and food choice. *Environmental Research Letters, 12*(6), 1-11.

Clonan, A.; Roberts, K. E. & Holdsworth, M. (2016). Socioeconomic and demographic drivers of red and processed meat consumption: Implications for health and environmental sustainability. *Proceedings of the Nutrition Society, 75*(3), 367–373.

Clune, S. J., Crossin, E., & Verghese, K. (2017). Systematic review of greenhouse gas emissions for different fresh food categories. *Journal of Cleaner Production, 140*(2), 766-783.

Cole, J. R. & McCoskey, S. (2016). Does global meat consumption follow an environmental Kuznets curve?. *Sustainability: Science, Practice, and Policy, 9*(2). 26-36.

Dietitians of Canada. (2016, October 28). Food Sources of Magnesium. Retrieved from http://www.dietitians.ca/Your-Health/Nutrition-A-Z/Minerals/Food-Sources-of-Magnesium.aspx

Dietitians of Canada. (2016, October 26). Food Sources of Fibre. Retrieved from http://www.dietitians.ca/Your-Health/Nutrition-A-Z/Fibre/Food-Sources-of-Fibre.aspx

Drewnowski, A.; Rehm, C.D.; Martin, A.; Verger, E.O.; Voinnesson, M & Imbert, P. (2014). Energy and nutrient density of foods in relation to their carbon footprint. *American Journal of Clinical Nutrition, 101*(1). 184-191.

Earle, L. (2013). *Traditional Aboriginal diets and health*. National Collaborating Centre for Aboriginal Health.

Environment and Climate Change Canada. (2017, June 28). Canada's emission trends. Retrieved from: https://ec.gc.ca/ges-ghg/default.asp?lang=En&n=E0533893-1&printfullpage=true

Econometric Research Limited, Harry Cummings & Associates & MacRae, R. (2015). *Dollars & sense: Opportunities to strengthen southern Ontario's food system*. Greenbelt.

Fischer, C. G., & Garnett, T. (2016). *Plates, pyramids and planets – Developments in national healthy and sustainable dietary guidelines: a state of play assessment.* Food and Agriculture Organization of the United Nations and Food Climate Research Network at The University of Oxford.

Food and Agriculture Organization (FAO). (2013a). Indigenous peoples' food systems & well-being: interventions & policies for healthy communities. [H. V. Kuhnlein, B. Erasmus, D. Spigelski, and B. Burlingame (eds.)]. Rome, Italy.

Food and Agriculture Organization (FAO). (2017). *The future of food and agriculture – Trends and challenges.* Rome, Italy.

Flynn, M.M. & Schiff, A.R. (2015). Economical Healthy Diets (2012): Including Lean Animal Protein Costs More Than Using Extra Virgin Olive Oil. *Journal of Hunger and Environmental Nutrition, 10*(4). 467-482.

Food Climate Research Network (FCRN). (n.d.). Why Food and Climate?. Retrieved from http://www.fcrn.org.uk/about/why-food-and-climate

Food Climate Research Network (FCRN). (n.d.). Foodsource. Retrieved from http://www.foodsource.org.uk/

Garnett, T. (2014). *Changing what we eat: A call for research and action on widespread adoption of sustainable healthy eating*. Food Climate Research Network.

Gerber, P.J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., … Tempio, G. (2013). *Tackling climate change through livestock – A global assessment of emissions and mitigation Opportunities*. Rome: Food and Agriculture Organization of the United Nations.

Harvard School of Public Health. (2016). Protein. The Nutrition Source. Retrieved from https://www.hsph.harvard.edu/nutritionsource/what-should-you-eat/protein/

Health Canada. (2004). Canadian Community Health Survey, Cycle 2.2, Nutrition Focus. Retrieved from http://www.hc-sc.gc.ca/fn-an/surveill/nutrition/commun/cchs_focus-volet_escc-eng.php

Health Canada. (2015). *Evidence Review for Dietary Guidance Technical Report*. Ottawa: Government of Canada.

Hever, J. (2016). Plant-Based Diets: A Physician's Guide. *The Permanente Journal, 20*(3), 93-101.

Institute of Medicine (IoM). (2014). *Sustainable Diets: Food for Healthy People and a Healthy Planet. Workshop Summary*. Washington DC: National Academies Press.

Intergovernmental Panel on Climate Change (IPCC) (2015). IPCC Expert Meeting on Climate Change, Food, and Agriculture. Retrieved from http://www.ipcc.ch/

Intergovernmental Panel on Climate Change (IPCC) (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. Geneva, Switzerland.

Jenkins, D. J. A., Sievenpiper, J. L.. Pauly, D., Sumaila, U. R., Kendall, C. W. C., & Mowat, F. M. (2009). Are dietary recommendations for the use of fish oils sustainable?. *CMAJ, 180*(6). 633-637.

Johnson, J. A., Runge, C. F., Senauer, B., Foley, J., & Polasky, S. (2014). Global agriculture and carbon trade-offs. *Proceedings of the National Academy of Sciences, 111*(34), 12342-12347.

Jones, A.D.; Hoey, L.; Blesh, J.; Miller, L.; Green, A. & Shapiro, L.F. (2016). A Systematic Review of the Measurement of Sustainable Diets. *Advances in Nutrition, 7*. 641-664.

Kumar, P.; Chatli, M.K.; Mehta, N.; Singh, P.; Malav, O.P.; Verma, A.K. (2017). Meat analogues: Health promising sustainable meat substitutes. *Critical Reviews in Food Science and Nutrition, 57*(5), 923-932.

Loladze, I. (2002). Rising atmospheric $CO_2$ and human nutrition: toward globally imbalanced plant stoichiometry?. *Trends in Ecology & Evolution, 17*(10), 457-461.

MacRae, R. Cuddeford, V. Young, S.B. Matsubuchi-Shaw, M. (2013). The Food System and Climate Change: An Exploration of Emerging Strategies to Reduce GHG Emissions in Canada. *Agroecology and Sustainable Food Systems, 37*(8):933-963.

McEvoy, C.T.; Temple, N.; Woodside, J.V. (2012). Vegetarian diets, low-meat diets and health: a review. *Public Health Nutrition, 15*(12). 2287-2294.

Medek, D. E., Schwartz, J., & Myers, S. S. (2017). Estimated effects of future atmospheric $CO_2$ concentrations on protein intake and the risk of protein deficiency by country and region. *Environmental Health Perspectives*, *125*(8), 087002-1 – 087002-8.

Melina, V.; Craig, W. & Levin, S. (2016). Position of the Academy of Nutrition and Dietetics: Vegetarian Diets. *Journal of the Academy of Nutrition and Dietetics, 116*(12). 1970-1980.

Motha, R. P., & Baier, W. (2005). *Impacts of present and future climate variability on agriculture and forestry in the temperate regions: North America.* Ottawa: Eastern Cereal and Oilseed Research Centre, U.S. Department of Agriculture.

Myers, S. S., Zanobetti, A., Kloog, I., Huybers, P., Leakey, A. D. B., Bloom, A. J. … Usui, Y. (2014). Increasing $CO_2$ threatens human nutrition. *Nature, 510*, 139–142.

Myers, S. S., Smith, M. R., Guth, S., Golden, C. D., Vaitla, B., Mueller, N. D., Dangour, A. D., & Huybers, P. (2017). Climate change and global food systems: Potential impacts on food security and undernutrition. *Annual Review of Public Health, 38*, 259 – 277.

Nelson, M.E., Hamm, M.W., Hu, F.B., Abrams, S.A., & Griffin, T.S. (2016). Alignment of Healthy Dietary Patterns and Environmental Sustainability: A Systematic Review. *Advances in Nutrition, 7*(6), 1005–1025.

Ontario Ministry of Agriculture, Food and Rural Affairs [OMAFRA]. (2016a). Climate change and agriculture. Retrieved from: http://www.omafra.gov.on.ca/english/engineer/facts/climatechange.htm#1c

Ontario Ministry of Agriculture, Food and Rural Affairs [OMAFRA]. (2016b). Ontario's local food strategy. Retrieved from: http://www.omafra.gov.on.ca/english/about/localfood.htm

Ontario Ministry of Agriculture, Food and Rural Affairs [OMAFRA]. (2016c). Introduction to organic farming. Retrieved from: http://www.omafra.gov.on.ca/english/crops/facts/09-077.htm

Pathak, H., Jain, N., Bhatia, A., Patel, J. & Aggarwal, P. K. (2010). Carbon footprints of Indian food items. *Agriculture, Ecosystems & Environment, 139*, 66 – 73.

Pecl, G.,T., Araujo, M. B., Bell, J. D., Blanchard, J., & Bonebrake, T. C. (2017). Biodiversity redistribution under climate change: Impacts on ecosystems and human well-being. *Science, 355*(6332), 1-9.

Rolfes, S. R., Pinna K., & Whitney, E. (2011). *Understanding Normal and Clinical Nutrition*. Wadsworth: Cengage Learning.

Schmidhuber, J. & Tubiello, F. N. (2007). Global food security under climate change. *Proceedings of the National Academy of Sciences, 104*(50), 19703-19708.

Seufert, V., Ramankutty, & N., Foley, J. A. (2012). Comparing the yields of organic and conventional agriculture. *Nature, 485*, 229-234.

Smith, P., Mercedes, B., Ahammad, H., Clark, H., Dong, H., Elsiddig, E., … Tubiello, F. N. (2014). Agriculture, Forestry and Other Land Use (AFOLU). In: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Statistics Canada. (2007). Canadians' eating habits: Findings. Retrieved from http://www.statcan.gc.ca/pub/82-003-x/2006004/article/habit/4148989-eng.htm

Statistics Canada (2012). Household food insecurity, 2011-2012. Retrieved from http://www.statcan.gc.ca/pub/82-625-x/2013001/article/11889-eng.htm

Statistics Canada (2017). 2016 Census of Population. Various geographies. Census Profile. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released September 13, 2017.

Stoll-Kleeman, S. & Schmidt, U.J. (2016). Reducing meat consumption in developed and transition countries to counter climate change and biodiversity loss: a review of influence factors. *Regional Environmental Change, 17*, 1261-1277.

Tan, K.T.; Lee, K.T.; Mohamed, A.R. & Bhatia, S. (2009). Palm Oil: Addressing issues and towards sustainable development. *Renewable and Sustainable Energy Reviews, 13*(2). 420-427.

Toronto Public Health. (2017). Toronto's Health Surveillance Indicator: Vegetable and Fruit Consumption. Retrieved from: https://www1.toronto.ca/City%20Of%20Toronto/Toronto%20Public%20Health/Performance%20&%20Standards/Health%20Surveillance%20and%20Epidemiology/Files/pdf/Surveillance%20Indicators/HSI_Vegetable&FruitConsumption-2017Jul25.pdf

United Nations Environmental Programme (UNEP). (2012). *The Critical Role of Global Food Consumption Patterns in Achieving Sustainable Food Systems and Food for All: A UNEP Discussion Paper*. Paris: Division of Technology, Industry and Economics.

Van der Weele, C. & Tramper, J. (2014). Cultured meat: every village its own factory? *Trends in Biotechnology*, *32*(6). 294–296.

van Huis, A., Itterbeeck, J. V., Klunder, H., Mertens, E., Halloran, A., Muir, G, & Vantomme, P.. (2013). *Edible Insects: Future prospects for food and feed security*. Rome: Food and Agriculture Organization.

Veeramani, A., Dias, G. M. & Kirkpatrick, S. (2017). Carbon footprint of dietary patterns in Ontario, Canada: A case study based on actual food consumption. *Journal of Cleaner Production, 162*(20), 1398 – 1406.

Weber, C. L., & Matthews, H. S. (2008). Food-miles and the relative climate impacts of food choices in the United States. *Environmental Science & Technology, 42*(10), 3508-3513.

World Resources Institute. (2016, April 20). Shifting high consumers' diets can greatly reduce per person land use and GHG emissions. Retrieved from: http://www.wri.org/blog/2016/04/sustainable-diets-what-you-need-know-12-charts

World Resources Institute. (2016, April). Protein scorecard. Retrieved from: http://www.wri.org/resources/data-visualizations/protein-scorecard