A case study on metrics | Greenhouse Gas (GHG) Emissions & Sequestration

A contributing paper to the Benchmarking Canada's Agri-Food Sustainability Leadership Project

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ABOUT THIS PROJECT
A diverse coalition of twenty-two partners (see cover page) came together in 2020 to consider the need for developing a national sustainability benchmark for Canada's agri-food sector.

The final report of the project's phase one was published in January 2021, *Benchmarking Canada's Agri-Food Sustainability Leadership – A Roadmap*. This work focuses on why better benchmarking is needed, how it can be expressed and what value it confers to society, sector competitiveness and policy-making. The report is to be used to engage even more Canadian agri-food stakeholders, setting the stage for phase two to proceed, index development.

ABOUT THIS CASE STUDY
Two case studies were conducted in support of this work and separately published, on GHGs/sequestration and on biodiversity. Case studies are seen as a way to bring diverse players together to work pre-competitively to assess and develop potential priority indicators to use in a national sustainability index. While not meant to be exhaustive, these high level overviews portray the global, national and marketplace context for benchmarking these specific matters, including the current state of metrics, the opportunities to better reflect Canada's performance and the gaps. As well, the cases identify what might enable or hinder metric development and implementation. The "case study model" is imbedded in the final report as an important part of the process to consider other indicators in future national index work.

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DMci Strategies

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SUMMARY

a) SWOT summary of issue: Greenhouse Gas (GHG) Emissions & Sequestration

Metric strength	Weakness
Canadian agriculture: >8% of its overall GHG emissions. **Global agriculture:** 23% world's GHGs.	• Canada does not have a total agri-food supply chain-wide GHG emissions metric from production to retail. • Several key data gaps, incl. fully accounting for soil organic carbon changes, trends & accounting for past progress on soil sequestration. A significant gap is validating the estimates. • Estimated region-based data used on nitrous oxide (N20) is collected now but the full effect of better nutrient stewardship to reduce these emissions is unavailable.
Metric opportunity	**Threat**

• Canada has a scientifically robust system of monitoring change in soil organic carbon but requires:
  ◦ More measurement to validate national estimates of soil organic carbon change – to more fully demonstrate agriculture's current role and future potential as "a carbon sink".
  ◦ Scientific evidence to demonstrate GHG mitigation progress from nutrient stewardship practices (e.g., revealing progress of reducing nitrous oxide could be a key opportunity).
• These efforts could be a means to offset the carbon tax while also helping to demonstrate compliance to Canada's Paris commitments.
• Visibility of "carbon-smart farming" is gaining global attention & Canada ag has the opportunity to document its leadership practices.
• GHG metrics that measure emission intensity is a comparative advantage that can be leveraged in the marketplace.
	• A global narrative presents Canada as a major emitter of GHGs per capita, economy-wide.
	• Urgency to lower GHGs now & the global net zero emission goal by 2050 will focus more on agri-food's footprint – affecting national & sector reputations & market access.

b) Elaborating on priority metrics to enhance/use

- Currently, the total contribution of agriculture's GHG emissions are measured as a percentage of Canada's total (i.e., just over 8%), as well as more granular views of specific GHGs.

- Every five years, Agri-Environmental Indicators data track soil organic carbon (SOC), carbon dioxide (CO_2), nitrous oxide (N_20), and methane (CH_4). Agriculture and Agri-Food Canada will be moving these indicators to an annual publication cycle. For instance, a soil organic carbon (SOC) indicator is now used to estimate how much CO_2 is removed from the atmosphere by plants and stored (or sequestered) as SOC in agricultural soils. The Relative Soil Organic Carbon (RSOC) Indicator assesses soil health and function, which varies across different climates and soil types.

- Improving GHG assessments and better reflecting positive agronomic practices can better present sustainable agricultural practices. Changes in nutrient management systems, particularly nitrogen application practices on farmlands, have significant impact on SOC and GHG emissions. Data and evidence of trends, especially for "4R" (good fertilizer) practices at regional and provincial levels, would improve the accuracy of estimating the changes in SOC and GHGs and is largely lacking and remains unaccounted for in SOC models or in inventory systems.

- As investors, companies and regulators increasingly consider the GHG footprint of food production and supply, an important limitation is that most of the data focuses on direct emissions from producers. A more complete picture – an entire supply chain view – would need to include emissions associated with getting agricultural products to the final consumer, such as transportation, processing and retail. Providing a detailed picture of emissions along the entire supply chain is currently a gap and would need to be further explored in terms of feasibility/resources.

IMPORTANCE OF METRIC

Why does measuring GHGs and sequestration matter?

a) Addressing GHGs is a key performance metric

- Measuring and reducing agricultural greenhouse gas (GHG) emissions is a recognized and urgent global priority by the vast majority of countries and many players across the global agri-food sector. GHG performance is a key indicator of sustainable food production (among many global indices).
- Globally, agricultural sectors and food companies are measuring their emissions reductions as part of their efforts to reduce GHGs and, for some, to transition to low- or zero emissions businesses and benchmark their respective overall environmental footprints.
- While attention focuses on reducing harmful GHGs, carbon is the basic building block of life and the main component of soil organic matter – vital to maintain soil health, quality and productivity. Soil acts as a storage reservoir (sink) for CO_2 captured from the atmosphere, a key sequestering function.[1]
- Measuring the extent to which agriculture/food production and supply exacerbates and/or manages GHG levels and sequesters carbon, and their trends, are significant indicators of environmentally responsible practices.

b) Canada is a leader

- Canadian agriculture has a relatively positive story to tell. Crop and livestock production contributes just over 8% of Canada's overall GHG emissions; whereas global agriculture represents some 23% of world's GHG emissions.[2] Over time, Canada has adopted innovative and world leading practices to improve its performance in this regard and, concurrently, increase agricultural productivity. However, the march to reduce emissions even further and mitigate the deleterious impact of climate change continues and agriculture is often cited as a major contributor to global GHG levels.

c) Effectively measuring GHGs

- Presenting a "balance sheet" approach would provide a more complete picture of greenhouse gases in agriculture. This includes measuring emissions (the outputs/"liabilities") and carbon sequestration (the inputs/"assets"), however measuring and validating sequestration has its challenges.
- Having the right metrics are essential to ensure evidence-based policy and regulation. Measuring GHGs on a per capita basis can portray Canada negatively. Whereas, measuring GHGs against a unit of production or emissions intensity could present a more accurate and favourable assessment. A lower GHG emissions efficiency vis-à-vis competitors is a comparative advantage. Canadian producers could present or market this feature as a major quality attribute.[3]
- Taking a supply chain view is also merited so to present a complete picture.

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[1] Soil holds twice as much carbon as the atmosphere and thus soil carbon storage is a vital ecosystem service, resulting from interactions of ecological processes. It is largely derived from recent photosynthetic fixation of CO_2 into sugars with the fixed carbon then translocated from leaves to roots, and where it is stored in both roots and the soil microbiome via organic exudates from roots into the soil. Most soils are far from saturated with organic carbon which, in addition to its importance for mitigation of climate change, also confers greater productivity of plants in natural environments and agricultural settings. The link between increased soil organic carbon and plant productivity is due in part to providing "food" for the soil and root microbiomes, which play key roles in improving root health and nutrient acquisition.

[2] "Efficient Agriculture as a Greenhouse Gas Solutions Provider," 2019, CAPI. Data is based on AAFC and IPCC data and is estimated and excludes on-farm energy use and energy used in the production of fertilizer. The UN indicates more recently that the food system accounts for 29% of global GHGs: https://www.un.org/sustainabledevelopment/food-systems-summit-2021/

[3] "Efficient Agriculture as a Greenhouse Gas Solutions Provider," 2019, CAPI.

REQUIREMENTS & EXPECTATIONS

What is being done now in Canada?

a) Regulatory and/or global obligations

- Canada measures GHG trends to support its annual reporting efforts under the U.N. Framework Convention on Climate Change. Addressing climate change is also cross-referenced to goal #13 of the U.N. Sustainable Development Goals. Canada's Federal Sustainable Development Strategy has pledged to progress against all goals and to improve sustainable food. Some provinces are aligning their environmental practices to the SDGs.

- Canada has pledged to reduce its total greenhouse gas emissions by 30% by 2030 and plans to achieve net-zero emissions by 2050. Canadian provinces also identify their respective GHG reductions.

- As the world grapples with climate change, the bar can be raised in other ways. To encourage greater GHG mitigation, the U.S. is contemplating the idea that food imports into that country must demonstrate its carbon offsets or be potentially subjected to a border carbon tax.[4]

b) Industry requirements and initiatives

- GHG data is being used by agriculture and food industry stakeholders to meet requirements for demonstrating sustainability criteria to buyers, including those for international market access.

- Many global and national food companies and a growing number of agricultural sectors have pledged to reduce the carbon footprint of producing and supplying food. To fulfill emissions reduction targets, major companies are also committing their agricultural supply chains to mark progress. CDP, a global standard for reporting on climate-related accountabilities notes that: "For most companies, the majority of their environmental impacts and exposures are to be found in their supply chains."[5] Scope 3 emissions (i.e., those occurring in a company's supply chains both up- and downstream) make up an average of 89% of food and beverage companies' total emissions.[6]

- Producer-driven initiatives, including in collaboration with companies, NGOs and others, have advanced the yardsticks, such as setting goals to reduce the greenhouse gas footprint of Canadian beef per unit of product produced (CO_2 eq./kg)[7] and developing carbon footprints for ten major Canadian grains and oilseeds crops.[8] In part, these initiatives aim to improve production efficiency.

- Global institutional investor-driven assessments, notably based on environmental, social and governance factors (ESG), include GHGs emissions reductions as a priority indicator of company and supply chain performance. ESG is going mainstream as companies are expected to report annually on such performance as a basis to assess credit and investment risk and to report to shareholders.

- Global organizations (e.g., World Economic Forum) are promoting carbon-smart (or

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4 *New Pressures for Renewal Demand a New Canadian Agri-Food Policy*, Douglas Hedley, Al Mussell & Ted Bilyea, Agri-Food Economic Systems, Aug. 2020: http://www.agrifoodecon.ca/uploads/userfiles/files/new%20agri-food%20policy%2010%20august%20ddh.pdf

5 *CDP Supply Chain: Changing the Chain*, CDP Supply Chain Report 2019/20. https://6fefcbb86e61af1b2fc4-c70d8ead6ced550b4d987d7c03fcdd1d.ssl.cf3.rackcdn.com/cms/reports/documents/000/004/811/original/CDP_Supply_Chain_Report_Changing_the_Chain.pdf?1575882630

6 Research conducted on 50 of the largest U.S. food and beverage companies; *Smarter metrics in climate change and agriculture*, WBCSD, March 2020: https://www.wbcsd.org/Programs/Food-and-Nature/Food-Land-Use/Climate-Smart-Agriculture/Resources/Smarter-metrics-for-climate-change-and-agriculture-Business-guidance-for-target-setting-across-productivity-resilience-and-mitigation

7 Canadian Roundtable on Sustainable Beef.

8 Canadian Roundtable for Sustainable Crops.

climate-smart) farming and soil sequestration is seen as its lynchpin to reduce GHGs, improve producer productivity and resiliency. Today, soils remove some 25% of the world's fossil fuel emissions annually.[9]

c) Addressed in global indices

- Taking action on climate change makes up nearly a quarter (24%) of the Environmental Performance Index, an assessment of 180 countries' environmental and biodiversity performance.[10] European countries dominate the list with 16 of the top 20 positions, with Canada ranking 20th overall. While Canada's ranking on sustainable nitrogen is 13th; its per capita GHG emissions ranks Canada 168th globally. The only indicator for "sustainable agriculture" identified in this index is this nitrogen metric.

9 World Economic Forum: https://www.weforum.org/agenda/2020/08/how-carbon-smart-farming-tackles-climate-change/?utm_source=sfmc&utm_medium=email&utm_campaign=2727909_Agenda_weekly-7August2020&utm_term=&emailType=Newsletter; https://blogs.ei.columbia.edu/2018/02/21/can-soil-help-combat-climate-change/

10 Environmental Performance Index, Yale Center for Environmental Law and Policy, 2020; Canada's ranking: https://epi.yale.edu/epi-results/2020/country/can

CURRENT STATE OF METRICS COLLECTION

What is prompting this matter to be benchmarked?

Metrics baseline
A baseline understanding of current practices is required before justifying/developing new indicators.

a) Are metrics/benchmarks now being published on this matter in Canada – and how is this being used?

- AAFC's Agri-Environmental Indicators data track soil organic carbon (SOC), carbon dioxide (CO_2), nitrous oxide (N_20), and methane (CH_4). Calculated every five years, the Indicators will be moving to an annual publication cycle.[11] (These measures are part of the Canadian GHG inventory held by Environment and Climate Change Canada and are reported to the UN Framework for Climate Change Convention.)

- The change in soil organic carbon (SOC) is a useful indicator of long-term, generalized trends in soil health. This benchmark gives a relative contribution of sequestration or mineralization that occurs in croplands to other sectors. The indicator estimates how much CO_2 is removed from the atmosphere by plants and stored (or sequestered) as SOC in agricultural soils. Thus, in addition to indicating changes in soil health, the change in SOC provides an indication of potential reductions in atmospheric CO_2, which can offset greenhouse gas emissions.

- In addition to knowing how quickly carbon is accumulating in the soil, it is useful to have a means of assessing soil health and function, which varies across different climates and soil types. A complementary measure, the Relative Soil Organic Carbon (RSOC) Indicator, was developed as a measure which can be used to compare the current SOC level across different regions and for different farming practice.

- Agricultural soils can be a net source or sink of CO_2. The net effect is the difference between CO_2 removal from the atmosphere by growing crops and its emission to the atmosphere through the decomposition of crop residues and soil organic matter. Management practices that promote the sequestration of carbon in soils tend to minimize soil disturbance and slow the rate of decomposition. These practices include decreasing tillage intensity, reducing the frequency of summer fallow and converting annual crops to perennial crops.

- Agricultural activities influence net GHG emissions from a variety of agricultural sources and sinks. Direct N_20 emissions originate from field-applied organic and inorganic fertilizers, crop residue decomposition, manure storage and cultivation of organic soils. Indirect N_20 emissions occur when nitrogen (N) is transported off-site through processes such as volatilization (loss of N to the air as a gas) and the subsequent deposition of ammonia, as well as N leaching and runoff (N dissolved in water). Methane is emitted through enteric fermentation, the process of feed digestion in ruminant animals, as well as through the anaerobic decomposition of stored manure.

b) Supply chain scope of metric? (i.e., Is the data available at every stage in food production/supply?)

- The picture is limited. Statistics Canada has good data available on direct emissions from agri-food producers (Table 38-10-0097-01) but those estimates lack information on specific agricultural industries (e.g., potato farming, beef production) and additional emissions occurring after the products pass through the farm-gate.

[11] Clearwater, R. L., T. Martin and T. Hoppe (eds.) 2016. *Environmental sustainability of Canadian agriculture: Agri-environmental indicator report series – Report #4.* Agriculture and Agri-Food Canada.

- Direct emissions estimates are provided for related industries (e.g., meat product manufacturing, dairy product manufacturing, etc.) Industry-level estimates are also available for direct plus indirect GHG emissions intensities (Table 38-10-0098-01) where direct emissions are those that are associated with the industry's own production and indirect emissions are those associated with the production of the goods and services that are used by the industry.

- One issue with GHG emissions estimates from the agri-food sector is their high level of aggregation (e.g., animal production, crop production). If desired, disaggregated data would help better understand emissions occurring during the production process of specific industries in the agri-food sector such as beef production or potato farming.

- Another important limitation is that most of the data focuses on direct emissions from producers, but a more complete picture would also include emissions associated with getting agricultural products to the final consumer, such as transportation, processing and retail.

- Statistics Canada produces GHG emissions data from its Physical Flow Accounts (PFA) and could potentially provide a more detailed picture of emissions along the supply chain through linkages with the Agriculture and Agri-Food Economic Account (AAEA). However, this would need to be further explored in terms of feasibility/resources. The PFA data is based on the global framework from the UN System of Environmental-Economic Accounting (SEEA).

c) What type of data is being used and what are some data sources?

- Canada's National Inventory Report tracks total GHG emissions and removals of carbon resulting from changes in agricultural and forestry land-use activities in the Land Use, Land-Use Change and Forestry sectors.[12] The source and sink estimates from croplands are reported by their types: (i) cultivation of organic soils, (ii) tillage conversions and (iii) perennial to annual crops and vice versa.

- Carbon stock change estimates rely on carbon factors and a time series of land management data in the *Census of Agriculture*.

- The Soil Organic Matter (SOM) Indicator combines two separate indicator models - the Soil Organic Carbon Change Indicator and the Relative Soil Organic Carbon Indicator – to assess how organic carbon levels in Canadian agricultural soils are changing over time. Land management practices include conversion to no-till, reduction in summer fallow and conversion of perennial forages to annual crops, and the subsequent sequestration or release of carbon dioxide.

[12] *National Inventory Report 1990-2018*. Greenhouse gas sources and sinks in Canada. Environment & Climate Change Canada, 2020.

GAPS & ISSUES

What's missing or needs to be addressed to advance the index concept?

a) Data gaps

- A challenge with the soil organic carbon (SOC) Indicator is the estimation of change (SOCC) over time. Significantly, over the past several decades there has been an increase in crop productivity due to introduction of high yielding varieties and efficient nutrient management systems. The increases in crop productivity is being addressed now in the revised SOC models.

- In 2018, the Canadian agriculture sector accounted for 76% of national N_20 emissions, up from 53% in 1990.[13] This rise provides only one side of the story. The effects of nutrient stewardship and impacts to N-use efficiency largely remains unimplemented, are largely estimated and it is likely that Canada is leaving a better picture of producer performance "off the table" because of inadequate field-level evidence. This is a metrics issue. One deterrent to getting better data is the burden it can place on producers, such as keeping seven years' records for farm audits. Producer organizations are embracing bold targets to reduce their GHG footprints (which also conforms to meeting global commitments), but the data collection processes can be refined to facilitate doing so.

- Changes in the nutrient management systems, particularly the nitrogen application practices in farmlands have significant impact on the SOC and GHG emissions. Data and evidence of trends especially for "4R" practices[14] at regional and provincial levels would improve the accuracy of estimating the changes in SOC and GHGs and is largely lacking and remain unaccounted in the SOC models or in the inventory systems. (Note, the maturity of the science around some "mitigation benefits" of 4R still need to be evaluated, requiring compilation and analysis of the current state of knowledge and further measures where scientific questions are inconclusive.)

- Having a full life cycle on-farm metric could be of interest as a potential gap is not including on-farm use of fossil fuels (contributing to CO_2).

- Provide a consolidated metric of Canada's agri-food GHG performance beyond the farm gate to include a consolidated view of distribution, processing, retailing, etc.

b) Metrics issues (challenges/ opportunities)

- A baseline understanding of current practices is required before justifying/developing new indicators. Example:
    - Canada is responsible for some 1.6% of global GHG emissions with this country's agriculture sector accounting for over 8% of this (2018).[15] In other countries, this agriculture number is higher and in some cases significantly. This Index should serve as a guide not only to encourage lowering this contribution but in presenting a comparative view of performance globally. As noted in the separate biodiversity case study, advances in precision agriculture and diverting unproductive marginal land to conservation are one means to achieve this positive outcome.

- While a fuller assessment of metrics challenges is required (including N_20 and CH_4), documenting the change in the amount of carbon stocked in soils might present a highly favourable view of Canadian agriculture but there is a lack of consensus on fulfilling this and on accounting for this. Demonstrating

13 Environment & Climate Change Canada.
14 4R Nutrient Stewardship encourages good fertilizer use at the right source, rate, time & place (Fertilizer Canada).
15 *National Inventory Report:* https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/sources-sinks-executive-summary-2020.html Note that agriculture accounts for 31% of national CH_4 emissions and 76% of national N_2O emissions.

whether Canadian agriculture is a net source or sink requires addressing past continuous improvements and progress on reducing GHGs and crediting that performance.

- There is complexity at two levels: Complexity of data collection increases at the farm-level, including accounting for regional variations (climate, soil conditions, practices) vs. taking broader survey or other data collection methods. Complexity of data collection is enhanced by taking a "supply-chain" approach.
- Consider land conversion and deforestation change. (This would provide a perspective on the actions taken to prevent conversion and deforestation). [Note: this issue is addressed in the "biodiversity" case study, under "marginal land changes".]
- Consider the health of water and aquatic systems such as oceans, lakes and rivers where fishing and farming take place and their role in the carbon cycle and sequestration. [Note: scope limitations of this case study did not include assessing water/oceans issues.]

c) Key policy issues

Sequestration & the carbon tax

Changes in Canadian tillage practices have already led to substantial increases in soil carbon but many other opportunities exist to extend this benefit. Such ecosystem services need to measured and incentivized. Properly measuring enhanced sequestration is not only a key metric to help improve on-farm productivity but it prompts a discussion as to whether this could be a means to offset the carbon tax while also helping to demonstrate compliance to Canada's Paris commitments.

The Federal Carbon Offset System

This program aims to provide credits to farmers who undertake projects that sequester or reduce greenhouse gas emissions, such as including livestock manure management, anaerobic digestion to produce biogas and improving soil organic carbon. Credits could then be sold to industrial facilities who exceed the emissions cap of their particular sector. Environment and Climate Change Canada has discussed measuring the uptake of these protocols by using "penetration rate." This would show how common an activity is in a given sector, expressed as the percentage of total potential uptake by producers. By aggregating data on producer sustainability efforts, such as via emerging data platforms/initiatives, the Index has potential to help measure the uptake of these protocols by Canadian producers. This in turn would help track progress on the sustainability targets identified by Index members and communicate the progress of Canada internationally.

Innovation priority

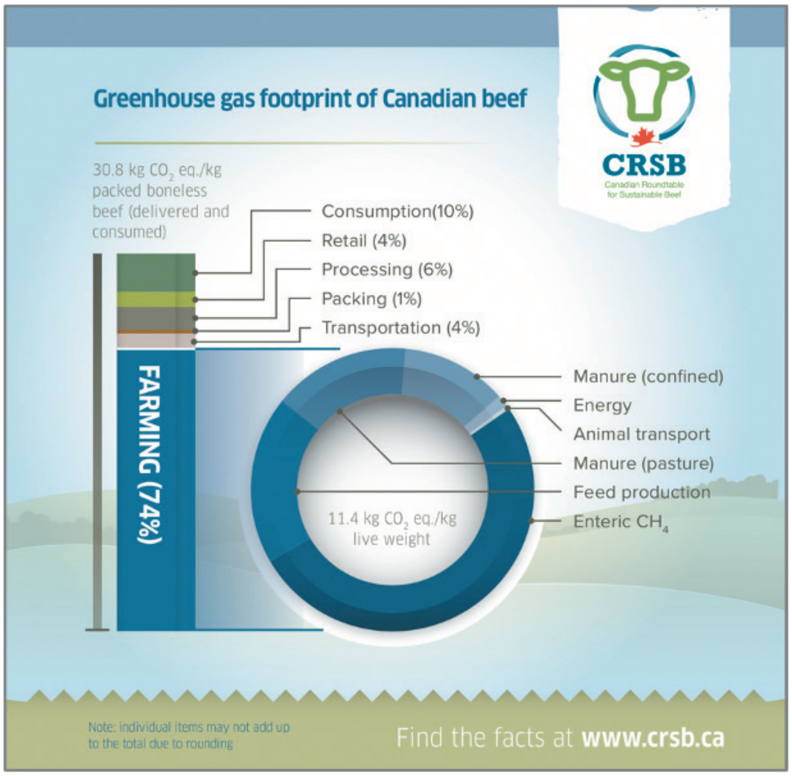
The breeding and selection of crops and forage grasses with deeper roots through modern breeding technologies and agronomic practices is one approach which can exploit new methods to enhance carbon sequestration in the soil as well as improve on-farm productivity. The use of extensive collections of crop and forage biodiversity in long established seed stores can accelerate carbon sequestration strategies by accessing natural diversity to breed deeper rooting varieties. This largely unused resource 'locked up' in extensive global seed stores offers a rich new source of 'natural' material to enhance crop breeding for many desired traits, including rooting depth and carbon sequestration. However, improved methods of measuring and modelling soil carbon, coupled with policy and market incentives, will be needed to stimulate innovation, deliver climate mitigating strategies and add value through both productivity and market accreditation of such "green approaches." Such innovation may be complemented by other agronomic practices, such as the use of crop rotations, leguminous perennial fallow, cover crops; encouraging such practices might require policy or market-based incentives. In short, better benchmarking requires aligning the country's innovation, research and technology capacity as well as aligning the players across the food system to make this happen.

Data management

To collect data and document on-farm GHG mitigation practices requires addressing data practices and strategy, such as addressing privacy concerns, collecting and sharing aggregated trend data. (A number of initiatives are now underway to explore how to more fully realize the benefits of better data practices.)

APPENDIX

A supply chain view of the GHG footprint of Canadian beef (Canadian Roundtable on Sustainable Beef, 2019)



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