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A GLOBAL INITIATIVE FOR THE UNITED NATIONS

The Food and Land Use Coalition

2019 Report of the FABLE Consortium

Pathways to Sustainable Land-Use and Food Systems

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2019 Report of the FABLE Consortium

Pathways to Sustainable Land-Use and Food Systems in Canada by 2050

Canada

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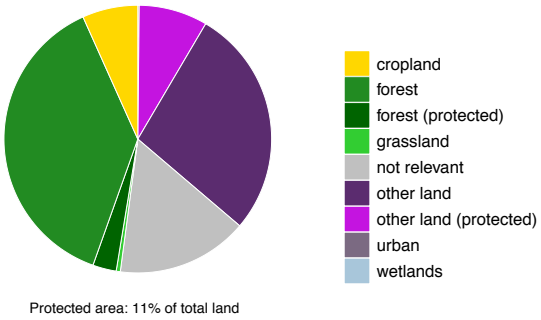
Land and food systems at a glance

A description of all units can be found at the end of this chapter

Land & Biodiversity

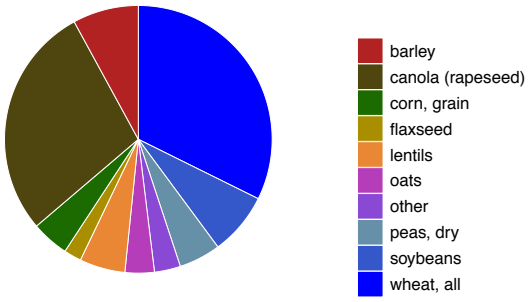
Fig. 1 | Area by land cover class in 2010



Protected area: 11% of total land

Source: Canadian Council on Ecological Areas, Statistics Canada (2015)

Fig. 2 | Share of harvested area by crop in 2015



Source: Agriculture and Agri–Food Canada (2015)

Annual deforestation in 2015:
40 kha = 0.02% of total forest area

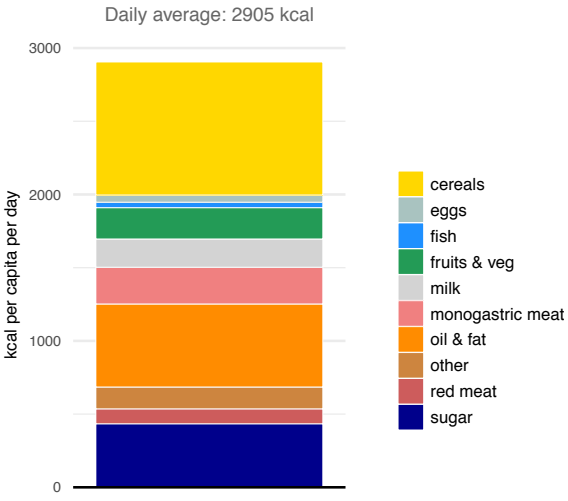
(Dyk et al., 2015)

Endangered species: 13

(Canadian Endangered Species Conservation Council, 2016)

Food & Nutrition

Fig. 3 | Daily average intake per capita at the national level in 2015



Source: Statistics Canada, FAOSTAT

Share of households that are food insecure:
1 in 8

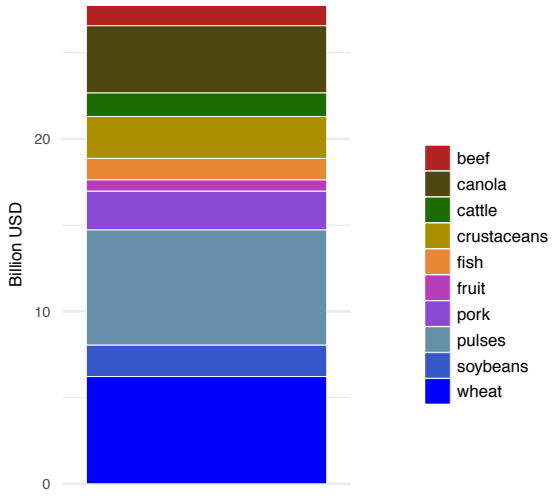
(Tarasuk et al., 2016; Health Canada, 2015)

Share of obese in 2015:
26.7%

(Health Canada, 2015)

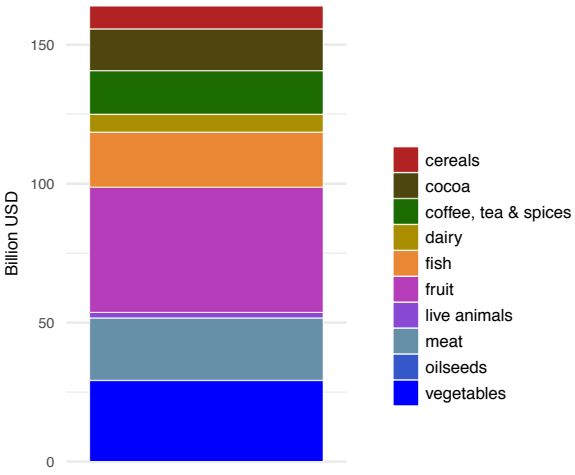
Trade

Fig. 4 | Main agricultural exports by value in 2015



Source: UN Comtrade Database

Fig. 5 | Main agricultural imports by value in 2015



Source: UN Comtrade Database

Surplus in agricultural trade balance in 2015: USD 13,542 mln

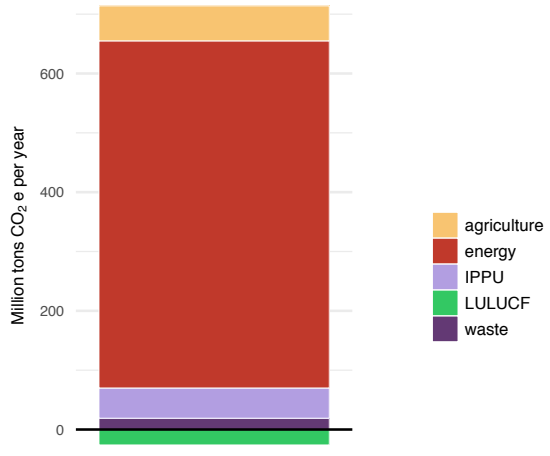
(Statistics Canada, 2019a)

#1 lentil and dry pea exporter in the world in 2015

(Statistics Canada, 2016)

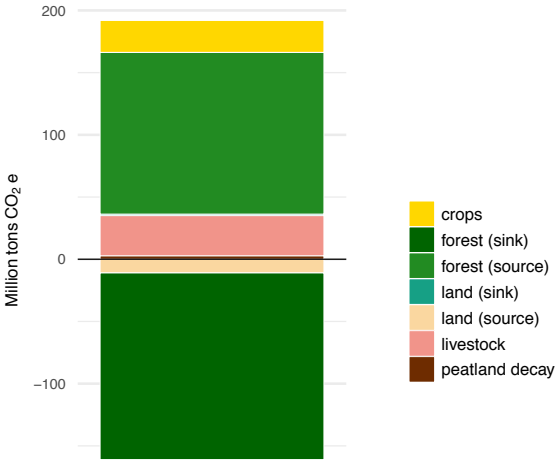
GHG Emissions

Fig. 6 | GHG emissions by sector in 2015



Source: Environment and Climate Change Canada (2018)

Fig. 7 | GHG emissions from agriculture and land use change in 2015



Source: Environment and Climate Change Canada (2018)

Main assumptions underlying the pathway towards sustainable land-use and food systems

For a detailed explanation of the underlying methodology of the FABLE Calculator, trade adjustment, and envelope analysis, please refer to sections 3.2: Data and tools for pathways towards sustainable land-use and food systems, and 3.3: Developing national pathways consistent with global objectives.

GDP GROWTH & POPULATION

	GDP per capita	Population
Scenario definition	GDP per capita is expected to increase from USD 50,070 in 2015 to USD 83,545 in 2050. The SSP2, "Middle of the Road" scenario was selected, assuming a medium economic growth with little deviation of social, economic and technological trends from historical patterns.	The population is expected to increase by 31.5% between 2015 and 2050 from 35.9 mln to 47.2 mln. The SSP2, "Middle of the Road" scenario was selected, which assumes medium fertility, medium mortality, medium migration, medium education and extension of current trends in urbanization. The population variation expected in this scenario is 1.54.
Scenario justification	Based on OECD Real GDP long-term forecast for Canada up to 2050. This publication was chosen because it contains useful and relevant forecasts and analysis of economic situations of the OECD member countries and formed the basis for scenario selection (OECD, 2018).	Based on Statistic Canada Population Projections for a medium-growth scenario. Statistics Canada has several medium growth scenarios which all roughly match the chosen scenario (Statistics Canada, 2018).

TRADE

	Imports	Exports
Scenario definition	The share of total consumption which is imported stays constant at 2010 levels.	The exported quantity increases: - from 18.4 Mt in 2010 to 36.8 Mt in 2050 for wheat, - from 7.4 Mt in 2010 to 14.8 Mt in 2050 for rapeseed, - from 2 Mt in 2010 to 4 Mt in 2050 for barley, - stays constant for the other products.
Scenario justification	Based on the Medium Term Outlook for Canadian Agriculture 2018 which assesses a historical agri-food domestic sales growth of 2.7% over the past 12 years and a 3.5% annual growth rate going forward. The domestic sales of agri-food products are expected to meet increased demand as a result of domestic growth, thus maintaining the share of consumption which is imported (Agriculture and Agri-Food Canada, 2018)	Based on the Medium Term Outlook for Canadian Agriculture 2018 which assesses a historical agri-food annual export growth of 6.5% over the past 12 years and forecasts 2% annual growth going forward. The growth of exports is indicated to come from multiple commodities but largely from the main exports, wheat and rapeseed (Agriculture and Agri-Food Canada, 2018).

Scenario signs no change small change large change

LAND

	Land conversion	Afforestation
Scenario definition	We assume that there will be no constraint on the expansion of the agricultural land outside beyond existing protected areas and under the total land boundary.	We assume no active afforestation and/or reforestation over the period of simulation.
Scenario justification	Based on the Statistics Canada Land Cover Data which is collected from land surveying and geospatial analysis. Canada has not committed to any deforestation schemes and there are currently no land-use change constraints other than regional zoning laws (Statistics Canada, 2019b).	Based on the Canadian Forest Service which does not track afforestation but does track regeneration (either through area planted or seeded) with new trees. In 2015, 425,000 hectares were regenerated through planting or seeding (Natural Resources Canada, 2018).

BIODIVERSITY

	Protected areas
Scenario definition	The protected areas remain the same over 2000-2050.
Scenario justification	The scenario does not reflect the 6th National Report to the Convention on Biological Diversity (CBD) by Biodivcanada which sets a 20% target for protected areas for 2020. Canada currently has 11% of its land under protection including parks, biosphere reserves, conservation areas and other protected areas (Biodivcanada, 2018).

Scenario signs = no change → small change ↗ large change

FOOD

	Diet	Food waste
Scenario definition	Between 2015 and 2050, the average daily calorie consumption per capita increases from 2,590 kcal to 2,618 kcal. Per capita consumption: - increases by 13% for fruits and vegetables, - increases by 20% for fish, - increases by 17% for other (includes nuts), - decreases by 15% for pulses. For the other food groups, there is no large shift in consumption.	Between 2015 and 2050, the share of final household consumption which is wasted decreases from 10% to 5%.
Scenario justification	Based on recommendations made in the recently released Canada Food Guide which recommends increasing the intake of fruits and vegetables and reducing intake of protein from meat. The food guide does not provide prescriptive recommendations but rather encourages eating a mostly plant based diet with whole grains and minimal processed foods (Health Canada, 2018).	Based on the Second Harvest Food Waste Roadmap, this publication lays out the roadmap for Canada to reduce avoidable food waste and loss through a 2018-2022 plan (Nikkel et al., 2019).

PRODUCTIVITY

	Crop productivity	Livestock productivity	Pasture stocking rate
Scenario definition	Between 2015 and 2050, crop productivity increases: - from 2.84 t/ha to 3.83 t/ha for wheat, -- from 5.69 t/ha to 9.06 t/ha for rapeseed (canola).	Between 2015 and 2050, the productivity per head increases: - from 103 kg/TLU to 115 kg/TLU for beef cattle, - from 600 kg/TLU to 900 kg/TLU for pork, - from 8.3 t/TLU to 9.3 t/TLU for cow milk.	The average livestock stocking density remains constant at 0.8 TLU/ha of pasture land between 2015 and 2050.
Scenario justification	Based on the Medium Term Outlook for Canadian Agriculture 2018, which forecasts an annual yield growth rate between 0-0.4% for wheat and 1.1-1.6% for rapeseed (canola) (Agriculture and Agri-Food Canada, 2018).	Based on the Medium Term Outlook for Canadian Agriculture 2018, which forecasts that herd sizes for dairy cows, beef cattle, and swine will increase slightly due to higher prices and demand. Relatively inexpensive feed is forecasted to contribute to farmers producing animals with higher average carcass weight (Agriculture and Agri-Food Canada, 2018).	Based on the report "Grazing Management in Canada" from Statistics Canada and based on data collected in the Farm Environmental Management Survey. There is a large amount of variation in livestock density by province which is expected to continue but the aggregate pasture stocking rate is expected to remain stable due to the large pasture land base (Rothwell, 2005).

Scenario signs = no change → small change ↗ large change

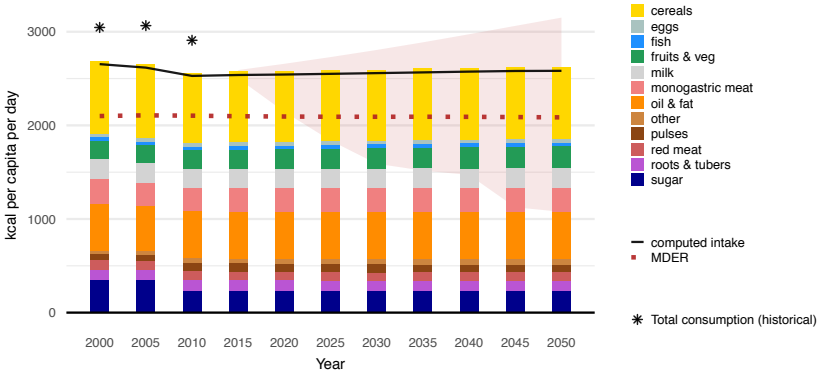
Results against the FABLE targets

The results for FABLE targets as well as "other results" are based on calculations before global trade harmonization.

Food security

Figure 8 | Computed daily average intake per capita over 2000-2050

Note: The Minimum Daily Energy Requirement (MDER) is computed based on the projected age and sex structure of the population and the minimum energy requirements by age and sex for a moderate activity level. Animal fat, offal, honey, and alcohol are not taken into account in the computed intake.



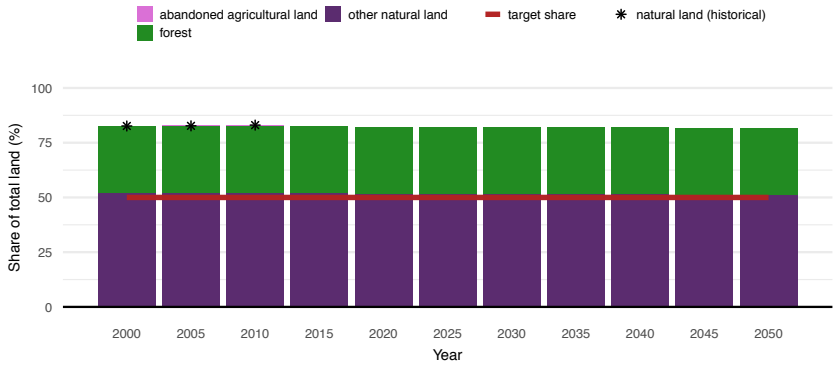
Historical data source: FAOSTAT

Our results show average daily energy intake per capita remains stable between 2,500 and 2,600 kcal from 2000-2015. This is 24% lower than Health Canada (2015) data due to some categories not being taken into account in our calculation. Over the last decade, 29% of the food intake came from cereals. Calorie intake reaches 2,600 kcal over the period 2031-2035 and remains stable over the period 2046-2050. In terms of recommended diet, our results show higher consumption of fruits and vegetables.

The computed average calorie intake is 23% higher than the Minimum Dietary Energy Requirement (MDER) at the national level in 2030 and 2050. Our results suggest that meeting national food security objectives will be attainable.

Biodiversity

Fig. 9 | Computed share of the total land which could support biodiversity over 2000-2050



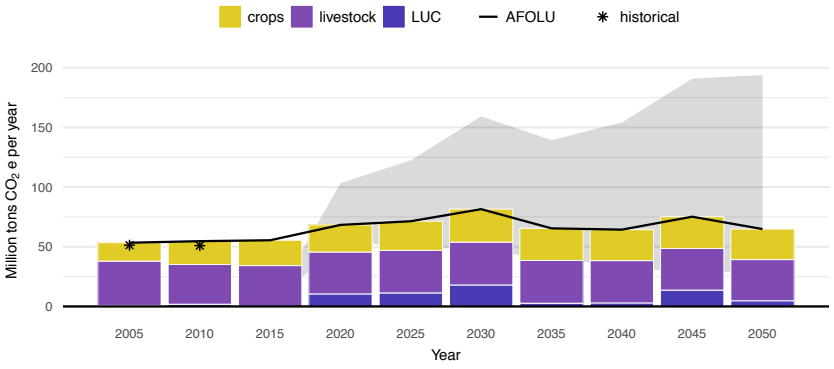
Historical data source: FAOSTAT

Our results show that the Share of Land which could support Biodiversity (SLB) remained stable between 2000-2015 at 83%. This number is similar to estimates based on Statistics Canada (2019b) land cover statistics. SLB remains stable over the whole period of simulation in the absence of significant land use change.

Compared to the global target of having at least 50% SLB by 2050, our results are above the target.

GHG emissions

Fig. 10 | Computed GHG emissions from land and agriculture over 2000-2050



Historical data source: FAOSTAT

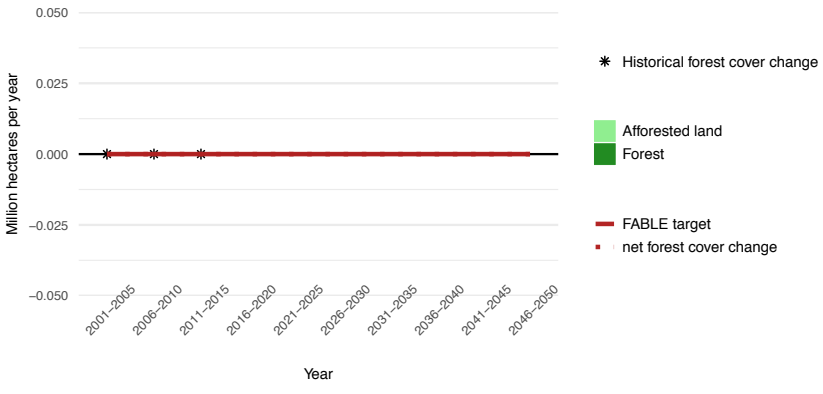
Note: AFOLU (Agriculture, Forestry and Other Land Use) is the sum of computed GHG emissions from crops, livestock and Land Use Change (LUC), emissions and sequestration from forestry are not included. Historical emissions include crops and livestock.

Our results show annual GHG emissions between 50 and 52 Mt CO_2e/year over 2000-2015 which increased over time. These are consistent with FAO statistics for GHG emissions from agriculture but this is higher than the Canada National Inventory Report which estimates a maximum of 26 Mt CO_2e/ year over the same period and a stable trend. Peak AFOLU GHG emissions are computed for the period 2030 at 80 Mt CO_2e/year. This is mostly driven by GHG emissions from LUC and crops. AFOLU GHG emissions reach 65 Mt CO_2e over the period 2046-2050: 60 from agriculture and 5 from land use change (LUC). Positive net emissions from LULUCF by 2050 are explained by the conversion of other natural land to urban area.

Compared to the global target of reducing emissions from agriculture and reaching zero or negative GHG emissions from LULUCF by 2050, our results are below the target. Our results show that AFOLU could contribute to as much as 5% of the total GHG emissions reduction objective of Canada (Environment and Climate Change Canada, 2018).

Forests

Figure 11 | Computed forest cover change over 2001-2050



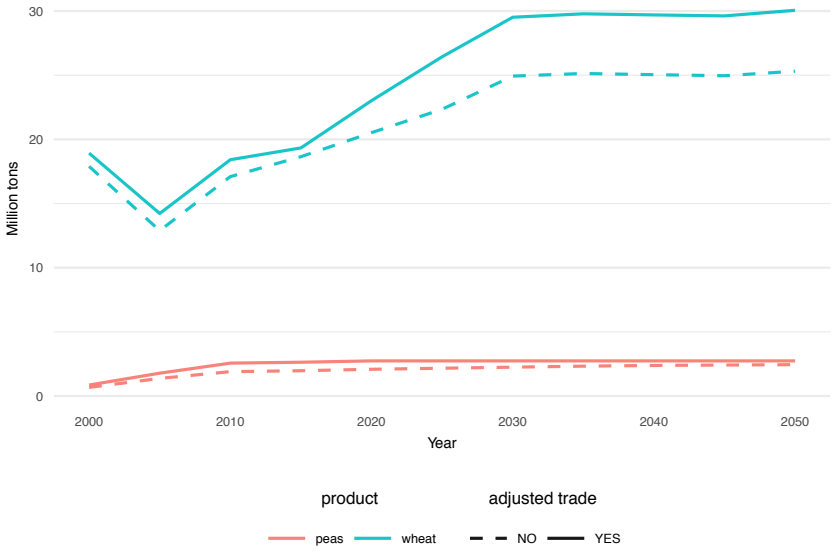
Historical data source: FAOSTAT

There is no deforestation computed from 2000-2015 which remains stable over time. This is consistent with FAO statistics but lower compared to the Canadian Forest Service (Natural Resources Canada, 2018) which estimates a maximum deforestation of 40 kha/year over the same period and a decreasing trend.

Compared to the global target of having zero or positive net forest change after 2030, our results are at the target. Our results meet national objectives of having less than 0.05% net forest cover change.

Impacts of trade adjustment to ensure global trade balance

Fig. 12 | Impact of global trade harmonization on main exported/imported commodities over 2000-2050

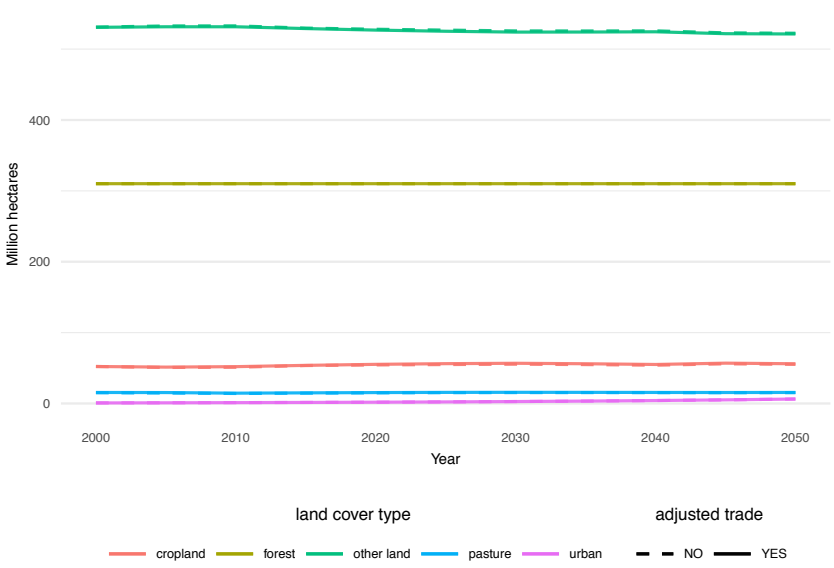


Trade adjustment leads to an increase of exported quantity for peas by 11.94% and for wheat by 18.76% by 2050.

Change in imports compared to no trade adjustment for fruits in 2050: +20%.

Change in imports compared to no trade adjustment for vegetables in 2050: +21%.

Fig. 13 | Impact of global trade harmonization on land use over 2000-2050



Trade adjustment does not lead to significant impacts on land use in Canada: cropland is reduced by 1.45% in 2050. By 2050, total AFOLU GHGs are reduced by 3.43% after trade adjustment.

Discussion and next steps

In developing a sustainable pathway for Canada, it was important to consider the advantages Canada has been conferred. As a land and resource giant with a small population, Canada is in the fortunate position of having low land-use impact due to the sheer size of the country and thus easily meets many sustainability targets such as low deforestation. Therefore, it was important to set challenging goals for Canada to meet in 2050 to ensure that achieving them was a result of substantial systemic change and did not end up being "business-as-usual".

Scenarios for the future were based on "middle of the road" projections for population and GDP growth, resulting in projections in 2050 with a population of 47 million and 120% growth in GDP. A sustainable diet was chosen that resulted in daily energy intake per capita remaining stable between 2,500-2,600 kilocalories with lower consumption of ruminants meats and sugars and higher consumption of fruits, vegetables and fish, which is consistent with the broad dietary recommendations set out in the latest Canada Food Guide (Health Canada, 2018).

A ambitious goal for reducing food waste was targeted as Canada is one of the worst countries in the world at wasting food with an average of 396 kilograms of food wasted per capita (Nikkel et al., 2019). In the FABLE Calculator, food waste in Canada is reduced from 10% to 5% by 2050. While this is an ambitious target, there are several agencies working in Canada on this issue and they have developed a comprehensive roadmap that could be a means by which to meet this goal.

Sustainable land-use targets included full compliance with Canada's commitment to the Convention on Biological Diversity, with 17% of terrestrial ecosystems and 10% of coastal and marine areas protected as well as keeping deforestation rates below 0.05%. As there is such a large land base, no restrictions on land conversion were enacted in this pathway through the FABLE Calculator, which resulted in very little land being converted between land use classes in the Calculator.

As Canada already has highly productive crops and livestock, productivity rate improvements were kept similar to current growth rates, with medium improvements seen in the yields of major crops (wheat, canola, pulses), and in the beef and dairy production rate. The results of the Calculator closely mirrored the expected government agricultural outlooks for the country, with quality parameters gaining increasing importance over quantity, particularly in the beef sector. Improvements in technology and germplasm as well as longer growing seasons and increased heat units are expected to increase crop yields in Canada, but there will also likely be yield penalties due to increased biotic and abiotic stress resulting from climate change and shifting agro-ecological zones.

The last part of the sustainable pathway was on developing scenarios for trade, and for Canada it was assumed that the share of consumption which is imported would remain stable (as part of the sustainable diet and meeting domestic demand with locally sourced products) and that exports would increase due to Canada continuing to play a role as a major exporter of agricultural products to Asia, the Middle East, and Europe. Adjusting for trade increased Canada's imports of key foodstuffs (fruits and vegetables, on which Canada is heavily reliant on imports) but also decreased exports of key commodities between 10-20%. Adjusting for trade had little impact of cropland area or total GHG emissions from land.

While using the FABLE Calculator has yielded interesting results and provided a pathway to a more sustainable future in Canada, there are several components not featured in the methodology that are important to the Canadian land and food systems. On average 2.5 million hectares of forest area burn every year in Canada and in 2016 over 15.5 million hectares of forest had been defoliated

by insects and contained beetle-killed trees. These statistics show that the actual extent of forest cover loss in Canada is much higher than deforestation or harvesting rates suggest. Natural forest disturbance from fire and pests, its acceleration due to climate change and its contribution to GHG emissions and reducing forest stocks are all important considerations when considering the future of Canada's landscapes and are not currently captured by the Calculator.

Another component of the Calculator that could be improved is the methodology for assessing biodiversity. The current calculation only includes land that could potentially support biodiversity, which is remarkably high in Canada (83%) due only to the vast wilderness and uninhabitable parts of the country. A more accurate calculation should consider biodiversity at the eco-region level to account for the differing amounts of protected land needed in the unique biospheres of world. Improvements could also come from including industrial crops, their contribution to energy systems as well their competition for land. Currently 25% of Canada's renewable energy comes from solid biomass, bioethanol, or biodiesel and this sector is expected to grow with the enactment of renewable fuels regulations and government commitments to 100% renewable energy as early as 2025.

Other useful considerations for the Calculator would be to include the emissions (or carbon sequestration) of different agriculture practices and cropping systems. Over 75% of the land area of the Canadian Prairies, the major agriculture region in the country, is in reduced or no-till which has been shown to improve biodiversity while reducing greenhouse gas emissions. Alternative cropping systems such as organic production are becoming increasingly common and have different land-use, biodiversity, and crop productivity outcomes that should be considered as part of a more holistic look at agriculture production at a country level.

The FABLE Calculator has set ambitious objectives for Canada to reach by 2050 in terms of increasing agriculture output while reducing carbon and land-use footprints. Technological innovation, such as the wide-scale adoption of precision agriculture, will likely be key in optimizing input and water use, reducing soil compaction, improving yields, and increasing overall productivity. While the implementation of precision agriculture still has a long way to go, adoption of some key technologies has been shown to be widespread among Canadian farmers including GPS guidance and yield monitoring on combines (Steele, 2017).

The implementation of sustainable pathways for Canada will require political action and buy-in at the local, provincial, and federal levels, as well as reconciling the economic incentives of resource-extraction with sustainability initiatives. Challenges to the realization of a more sustainable future are further constrained by the lack of data on the evolution of land and food systems, as this data is controlled by the national statistics body of Canada and not available at finer scales. Modelling future land-use scenarios will require this data as well as better tracking of other land-use statistics including afforestation efforts. The disconnect between environmental, natural resource, and agricultural policymakers on sustainability issues is another challenge that needs to be addressed in the Canadian context in order for the sustainable pathways to be implemented.

Recommendations to develop integrated policies to address these challenges include increasing forest replanting to offset AFOLU GHG emissions, enacting policies to further protect natural land, pasture and agricultural land from land-use change, developing climate change adaptation plans for shifting agri-ecological zones, and making agriculture and land-use microdata available for better modelling and land-use planning. Canada is fortunate to have the political will and the means to enact many of the changes needed to put the country on a path to sustainability and now has (at least partially) a roadmap to do so.

Units

% – percentage
bln – billion

cap – per capita

CO_2 – carbon dioxide

CO_2e – greenhouse gas expressed in carbon dioxide equivalent in terms of their global warming potentials

GHG – greenhouse gas

Gt – gigatons

ha – hectare

kcal – kilocalories

kg – kilogram

kha – thousand hectares

km^2 – square kilometer

kt – thousand tons

Mha – million hectares

mln – million

Mt – million tons

t – ton

TLU –Tropical Livestock Unit is a standard unit of measurement equivalent to 250 kg, the weight of a standard cow

t/ha – ton per hectare, measured as the production divided by the planted area by crop by year

t/TLU, kg/TLU, t/head, kg/head- ton per TLU, kilogram per TLU, ton per head, kilogram per head, measured as the production per year divided by the total herd number per animal type per year, including both productive and non-productive animals

tln – trillion

USD – United States Dollar

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