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Competing Pressures on Land Use in Canadian Agriculture: To Intensify or Not to Intensify- That is the Question

A *Research* Report prepared for CAPI by
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Research
Report

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Note from CAPI

CAPI's recent focus on trade, food security and the changing geopolitical and market environment along with climate change have helped identify some of the key new challenges and opportunities facing the Canadian agriculture and agri-food sector in this new world of scarcity not abundance. These developments are putting pressure on Canada's natural capital and resources including land use. For this reason, CAPI was tasked with identifying competing pressures for land use in Canadian agriculture and proposing potential policy solutions that will ensure Canada can continue to produce and export high quality sustainable agriculture and agri-food products for Canadians and the world well into the future.

Key Takeaways

In light of the new world of scarcity, geopolitical turmoil and growing food insecurity, the Canadian agriculture and agri-food sector faces competing pressures that threaten its future sustainable land use. These include:

- Canada, being a major producer and net exporter of high-quality sustainable agriculture and agri-food products, will face pressures to produce more to meet the demands of countries experiencing population growth, urbanization, and increased food demand.
- **Commodity shortages** and price spikes due to food scarcity will also exert upward pressure on prices, costs, farm income and land values, putting pressure on land conversion;
- **Biofuel mandates** and current agriculture support measures are also exerting pressure on prices and land use and need to be reassessed to preserve land (and food security) for future generations.
- **Climate change** and extreme weather events are impacting productivity growth, risking insufficient food production. Investments in R&D, infrastructure, better data and knowledge and technology transfer are key for future sustainable productivity growth, which can help achieve food security while minimizing environmental impacts and protecting land use.
- **Policies promoting land zoning and protection of sensitive ecosystems** must become an important part of the toolbox, drawing from international examples like the EU, U.S., and traditional Indigenous knowledge.

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Introduction

In light of the pandemic, the Russian invasion of Ukraine and rising protectionism and inflation, the world finds itself in a new era of rising food prices and increased food insecurity around the world.[1] At the same time, climate change, biodiversity loss and the degradation of land and freshwater are threatening the earth's future ability to sustain and feed the world's growing population. Pressure will continue to force expansion of croplands to feed the world. Agriculture has a role to play and can lead in finding solutions to ensure the future sustainable growth of agriculture and food production. This will require a fine balance between land use extensification- treading more lightly on existing land while expanding land use, and intensification - treading more heavily on existing land without expansion.

Can Canada do this sustainably? How will this impact Canada's commitments to reduce Greenhouse Gas emissions (GHGs) and biodiversity loss? Will Canada need to convert more of its forests, grasslands and wetlands to food production at the same time that population pressures threaten more urban development on class A farmland? To find a balance between intensification and extensification requires producing "more and better with less", known as 'sustainable intensification" based on total factor productivity growth that boosts food production with fewer negative environmental impacts (Tillman et. al. 2002, Coomes et. al. 2019). This paper describes the competing pressures on agricultural land use in both the global and Canadian context. It will look to international examples of policies and initiatives that address these pressures with an eye to propose potential solutions for Canada on how it can preserve its agricultural land use for future generations.

1. Global Context

1.1 Land Use: The Earth has limited resources

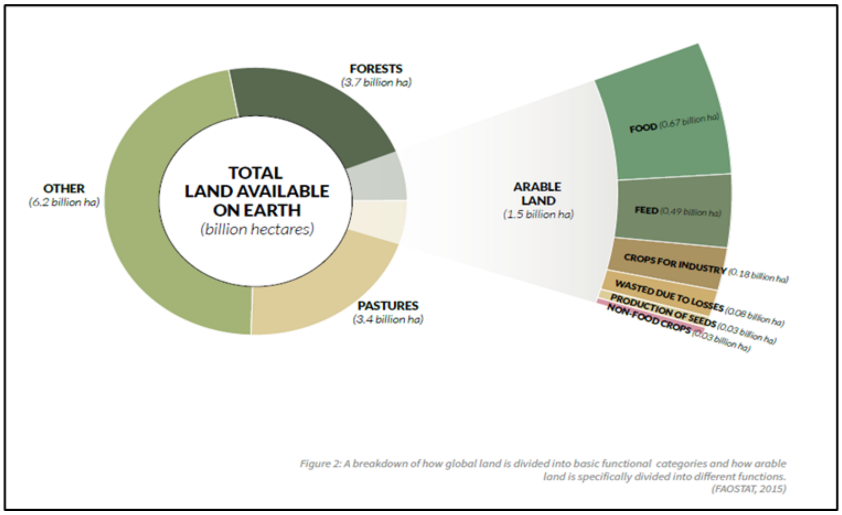
Of the total 13 billion hectares(ha) of global land area in 2015, about 1.5 B ha were used for crop production, (arable land and permanent crops) and 3.4 B ha were used to pasture animals (Figure 1) (FAOSTAT). Agricultural land best suited for farming represents 36% of the earth's terrestrial surface and almost 50% of its vegetated area with the rest covered by deserts, mountains, tundra, cities, ecological reserves and other lands not suitable for agriculture (Foley et. al. 2011, pg. 1).

Cropland serves many purposes beyond just food production. In addition to food (45% of cropland) it provides feed for livestock (33%), seeds for inputs (2%), and food and non-food crops for industrial uses such as renewable biofuels (14%)(FAO, 2015). Between 1961 and 2019, cropland increased by 208 million ha (15%) while permanent pasture for livestock declined 200 million ha to 3.2 B ha in 2019. Available agricultural land for crops and livestock now stands at less than 0.64 ha per person globally.

In 2020, Canada, with 38.4 Mha, was the 8th largest country in terms of cropland area after India (169 Mha), the U.S. (160 Mha), China (136 Mha), the Russian Federation (123 Mha) and Brazil (64 Mha), Nigeria (Mha) and Indonesia (Mha). Over the period 2000 to 2020, cropland area declined in the United States (-10%) and Canada (-7%) but increased in Indonesia (+43%), Argentina (+18%) and Brazil (+16%) due to land clearing and deforestation.

[1] See CAPI's *What We Heard* Report from the January 31, 2023 Conference "Canadian Agri-food in a Hungry World" held jointly with the Canadian Global Affairs Institute(CGAI) and the Canadian Agri-food Trade Association (CAFTA) for a description of the current trade environment impacting Canadian agriculture and agri-food. Available here: [What We Heard_CdnAgriFood - EN (capi-icpa.ca)]

Figure 1: Global Land Use, 2015



Source: Gladek, E. et al. (March, 2017) The Global Food System: An Analysis, p.20.

1.2 Pressures from Population, Income and Demand Growth to 2050

Global population growth will continue to exert pressure on land use into the future. The world's population is expected to reach 9.7 billion by 2050 after reaching 8 B in November 2022 (UN world Population Prospects, 2022, p. 3). Population growth, which fell below 1% per year for the first time in 2020, has slowed by more than half since the 1960s due to reduced fertility rates in most developed countries. In Sub Saharan Africa (SSA), however, the population will double, surpassing 2 B inhabitants by the late 2040s since fertility rates will remain close to 3 births per woman until 2050 (p.3). At the same time, 70% of the world's population will live in cities in 2050, up from 54% in 2015 (FAO, 2017, p.14). Given these projected population increases, there will be increased pressure on land use expansion from growing demand for food, non-food uses and housing onto agricultural and natural lands. While it may be difficult to return agricultural lands to nature once they have been plowed up, it is near impossible to return urban concrete jungles to agricultural land once they are paved over. Without accompanying improvements in yields and land intensification, the world will become a more crowded and hungrier place.

In Canada, the 2021 Census of Population counted 38 million people (up 5.2% from 2016), making Canada the fastest growing country in the G7 over the 2016 to 2021 period.[2] Most of this growth came from immigration rather than natural increase, with nearly three out of four Canadians living in Canada's large urban centres (with population of 100,000 more). Rapid population growth in cities is increasing the need for infrastructure, transportation and services of all kinds with urban sprawl raising environmental concerns, such as car-dependent cultures and encroachment onto farmlands, wetlands and wildlife. [3] Canada's population is expected to rise to between 45 million to 74 million by 2068 [4] and this will put more pressure on land use in Canada. Thus, more thought needs to be given on how to prevent urban sprawl and land use conversion, protect valuable agricultural land for Canada's future food production capacity.

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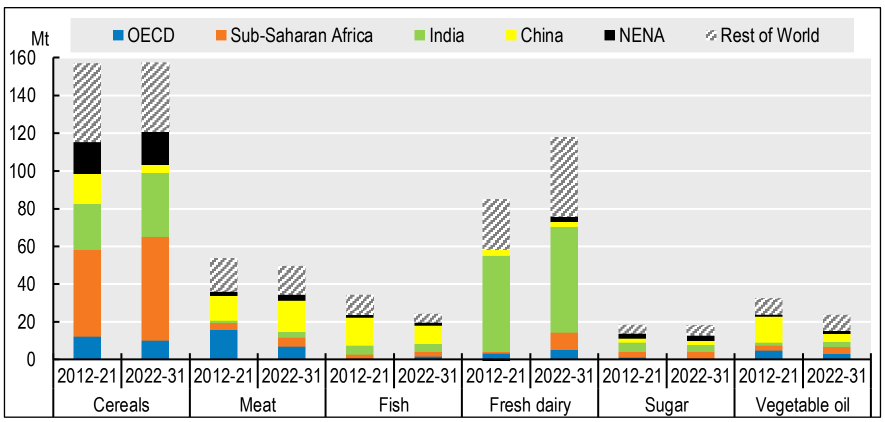
[2] Statistics Canada Daily, Canada Tops G7 Growth despite COVID. Available here: The Daily — Canada tops G7 growth despite COVID (statcan.gc.ca)
[3] Statistics Canada, Daily, Census of Population 2021, "Canada's large urban centres continue to grow and spread", February 9, 2022.
[4] Statistics Canada, Daily, Population Projections to 2068. Available here: Population Projections for Canada (2021 to 2068), Provinces and Territories (2021 to 2043) (statcan.gc.ca)

1.3 Growing meat demand will put pressure on land use and generate GHG emissions

Between 1961 and 2009, animal-based protein consumption grew by 59% per capita globally while that of plant-based protein grew by only 14%. According to the OECD-FAO Outlook, 2022 to 2031, global food demand will increase by 1.4% per year over the next decade, driven by population growth and income growth. Demand in high-income countries will be constrained by slower population growth and a saturation in per capita consumption. However, low and middle-income countries, such as India and SSA are expected to experience faster GDP growth, driving demand for higher value food products. Bennett's law states that the proportion of the food budget spent on starchy-staple foods declines as incomes grow in developing countries, leading to higher demand for animal-based products (Godfray, 2010)(Figure 2). Meat and fish demand will grow in China, and India is expected to demand more dairy products as both its population and income grow over the period. High demand for protein, projected to grow by 68% to 2050, will put pressure on agricultural resources since animal-based protein requires disproportionately more agricultural land and water for production than plant-based products (Rask and Rask, 2011).

Figure 2: Regional Contributions to Food Demand Growth, 2012-2021 and 2022-31



Source: OECD-FAO, Agricultural Outlook, 2022-2031.

Searchinger et. al. (2019) estimated the additional land and GHG emissions required to produce more protein from different foods. Meat from ruminants requires over 20 times more land and generates over 20 times more GHG emissions than pulses per gram of protein (p. 76). With expected increases in demand for animal-based products, livestock production will need to become more efficient and productive to avoid further expansion of pasture and cropland. Without this, Searchinger (2019) estimated that the increased demand for meat and milk in 2050 will require an additional 2.5 B ha of cropland and pasture area, releasing 20.6 Gt CO2e in land-use change emissions each year (p. 174). Even with livestock efficiency improvements, pasture area is projected to increase between 401 Mha and 523 Mha to 2050, at the expense of forests and woody savanna (p. 21).

1.4 Growing Demand for Biofuels and Land Use Impacts

According to Bloomberg, the world is about to experience a "biofuels crunch".[5] The increased demand for soybean, canola and palm oil as feedstock for biodiesel and renewable diesel, has led to supply shortages and price increases. Biofuels/biodiesel production and consumption are determined by policies that mandate the share of renewable fuels and diesel in fossil fuel blends in any country. In Canada, several provinces mandate clean fuel standards that require fuel suppliers to blend 5-10% of renewable content in gasoline and 2-5% in

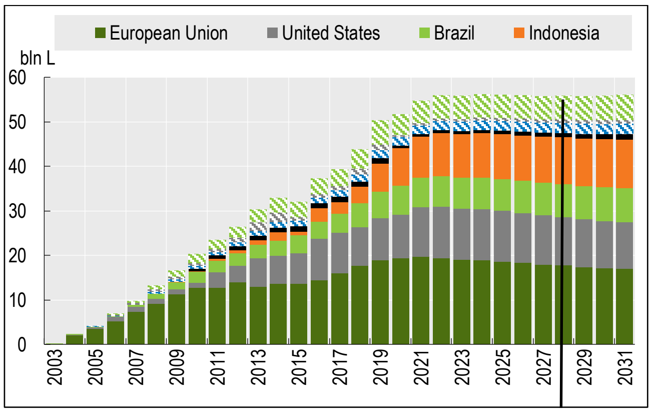
[5] Bloomberg, March 21, 2023, [Shortage of Cooking Oil Looms as Biofuels for Trucks, Planes Gain Global Appeal - Bloomberg]

diesel, with increases in mandates projected into the future.[6] Hence, biofuel production is a function of fossil fuel demand and energy prices – when they go up, so does biofuel/biodiesel production.

In 2021, after COVID restrictions, global demand for fossil fuel and biofuels/biodiesel rose and consumption increased to 126 B Litres for biofuels and 55 B L for biodiesel (OECD, 2022 p. 234). However, biofuel/biodiesel demand is expected to increase at a much slower rate as support policies are reduced in developed countries (Figure 3). For example, the EU's Renewable Energy Directive (RED) II classified palm oil-based biodiesel as a high risk category for Indirect Land Use Change (ILUC) from deforestation (OECD, 2022 Ag Monitoring, p. 233). Thus, the EU has cut-back on biodiesel production and prices have risen.

Searchinger et. al. (2019) estimated that if biofuel's share in transportation fuels is raised to 10 percent globally, an additional 106 Mha of land and annual GHG emissions of 1.3 Gt would be needed. However, to phase-out biofuels would reduce land use by 28 Mha in 2050 and agricultural GHG emissions by 330 Mt CO2e per year (p. 113), a preferable option.

Figure 3: World Biodiesel Production Projections, 2022-2031



Source: OECD-FAO. Agricultural Outlook, 2022-2031.

1.5 Crop Yields must increase faster than in the past 30 years to meet growing world demand

The OECD (2022) projects that crop yield growth will account for 80% of crop production increases to 2031. This will be due to higher inputs- worldwide fertilizer applications (nitrogen, phosphorus and potassium) peaked in 2017 at 192 MT/year (FAOSTAT, Fertilizers by Product, 2020) with pesticide use stable at around 4 MT/year. Also needed will be improvements in genetics, investments in new production technologies along with improved management pactices, expanded irrigation systems and increased farmer access to hybrid seeds, synthetic fertiliers and pesticides (OECD, 2022 Outlook, p. 47). Searchinger et. al. (2019) argue that in order to meet future demand without land expansion, yields of grains and other crops such as fruits and vegetables, soybeans, pulses, and roots and tubers will need to grow about 10% faster than current rates over the 2010 to 2050 period (p. 154). This implies greater agricultural land use intensification.

[6] Government of Canada: What are the Clean Fuel Regulations? - Canada.ca

2. Technological Change and Land Use- Does it Lead to Intensification?

Mussell argues that there are two ways to meet the expected global demand for food: (1) convert land into agricultural use currently in some other use, or (2) increase output from existing agricultural land (Mussell, 2014). The former increases agricultural production by converting land from other uses (extensification); the latter increases production by using land more intensively (intensification). These two alternatives are not equivalent, particularly in terms of environmental sustainability.

> The Borlaug Hypothesis: "Technological change improves productivity on existing agricultural land and hence is "land sparing", leading to intensification and saving natural ecosystems from being converted to agriculture"
> – Norman Borlaug, Father of the Green Revolution

The extensive approach allows for reduced input use- fertilizers, pesticides. It may be consistent with more traditional farming methods as a lower risk approach. However, land in pristine condition provides benefits such as wildlife habitat, wetland/groundwater recharge, carbon sequestration, etc. Thus, by "treading more lightly" on existing land and expanding onto natural lands, actually increases agriculture's footprint. At the same time, using more land intensively often requires greater input use, such as fertilizers and pesticides with harmful environmental impacts. This leads to the need for a third option centred around total factor productivity growth that improves sustainability and resilience of agricultural production on farm landscapes over time.

2.1 The Importance of Productivity Growth for Food Security and Efficient Land Use

Increasing crop and livestock yields, which are partial productivity measures, have been key to ensuring there has been an abundant and affordable supply of food for a growing world population. Despite the difficulty with data availability to estimate these metrics, studies have shown that the Green Revolution in the 1960s saw dramatic increases in yields, contributing to declines in real commodity prices, around 1% per year on average between 1900 and 2000, even as the world's population tripled (Fuglie et. al. 2021, p. 3). This led to improved access and affordability of food to millions.

Norman Borlaug, the father of the Green Revolution, had argued that technological change improves productivity on existing agricultural land and hence is "land sparing", leading to intensification and saving natural ecosystems from being converted to agriculture (the "Borlaug Hypothesis") (Stevenson et al. 2013). In fact, Stevenson et. al. (2013) estimated that genetic improvements in major field crops between 1965 and 2004 during the Green Revolution saved between 18 and 27 million ha of land from conversion into agricultural use. Foley et. al. (2011) observed that "to meet the world's future food security and sustainability needs, food production must grow substantially while, at the same time, agriculture's environmental footprint must shrink dramatically".

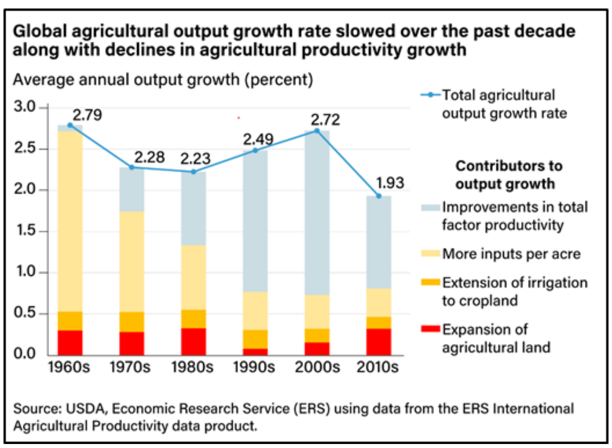
Morgan, Fuglie and Jelliffe (2022) estimated the contribution of intensification, extensification and total productivity growth (TFP) for this outstanding growth in food production since the 1960s. TFP is a broad agricultural productivity metric that accounts for the contribution of all inputs to production, calculated as a ratio of agricultural output (both crop and animal products) to total inputs (land, labour, capital and resource inputs). This compares to partial productivity metrics which focus on individual factors of production such as land area (yield per hectare) and specific commodity output (e.g. litres per cow) (Coomes et. al. 2019, p, 24). Figure 4 shows the relative contribution of input growth, irrigation and cropland expansion to agricultural production in each decade since the 1960s as estimated by Morgan et. al (2022). In the 1960s, the main driver of output growth was increased inputs, such as fertilizer and irrigation use in Asia and South America that came with new crop varieties and yield growth (Coombs et. al. 2019). This led to greater land use "intensification". Agricultural output grew by 2.79% per year that decade and TFP growth contributed little to output growth. During the 1970s, TFP growth expanded in most developed countries as new technologies were broadly disseminated and adopted. During the 1980s and 1990s, technology spillovers spread to Brazil and China from crop germplasm research

(Pardey et. al. 1996). In the 1990s and 2000s, TFP growth drove 75% of the output gain versus 5% in the 1960s. However, since the 2010s, both agricultural output and TFP growth have slowed in developing countries and cropland expansion has become more of a driver. Clearly, for future TFP growth, increased development, adoption, and diffusion of new agricultural technologies and management practices will be required (Pardey et. al. 1996, Fuglie et. al. 2019, Baldos et. al. 2014).

Morgan et. al (2022) explain this recent TFP slowdown partly by climate change and weather shocks such as drought, which have led to lower agricultural yields. Research by Lesk et. al. (2016) found that drought and extreme heat over the 1964 to 2007 period impeded global cereal production by 9-10%, equivalent to 6 years of production growth. Steensland et. al. (2022) also found that global TFP grew slower by 0.46 percentage points in years of extreme climate events over the 1961 to 2016 period. Specifically, they found that droughts had three times the impact on TFP growth while wildfires had six times the impact, compared to the average. Ortiz-Bobea et. al. (2021) also showed how climate change lowered TFP for global agriculture by about 21% since 1961, equivalent to the loss of 7 years of productivity growth. The impact was more severe in warmer tropical regions such as SSA and Asia, while northern regions like Canada actually benefited from the warmer temperatures. In fact, (Qian et. al. 2020) showed that Canadian wheat and canola yields increased as a result of global warming while maize yields decreased.

Other factors that have been used to explain this slowdown in TFP growth include the emergence of new pests and diseases such as disease-resistant weeds that have reduced crop yields, requiring additional inputs and management practices (Morgan et. al. 2022). Fuglie et. al. (2021) argued that market access barriers in international trade hindered productivity growth as a result of poor infrastructure, high market transaction costs, inconsistent regulatory frameworks and tariffs, driving up costs of new productivity-enhancing technologies and inputs, limiting opportunities for the transfer of technologies and for achieving efficiency gains in countries with a competitive advantage.

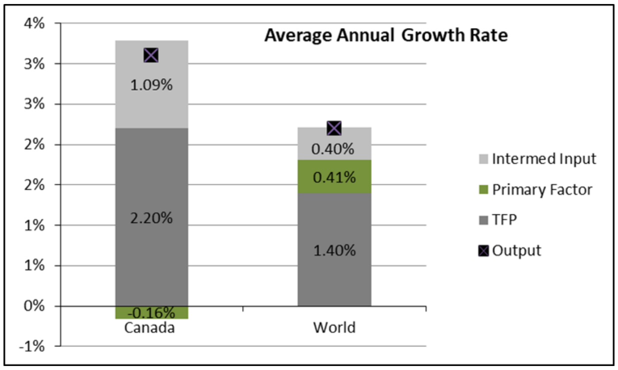
Figure 4: Contribution of TFP, Inputs, Irrigation and Land Use to Output Growth, 1960-2010s



Source: Morgan, Fuglie and Jelliffe. 2022. Amber Waves. USDA.

Canada's agricultural output growth also slowed since 2010 and was also driven to a large extent by TFP growth as opposed to input growth, with output growth of 3.1% per year due to a 2.2% increase in TFP growth and a 1.09% increase in intermediate input use (Figure 5). Land use contracted as land was used more intensively (neg .16%). This compares to the world, where TFP played a smaller role and land use expanded by 0.41%.

Figure 5: Canada and World: Composition of Agricultural Output Growth, 2010-2019



Source: OECD, 2022 Ag Monitoring Report

2.2 Productivity Growth, Trade and Land Use Intensification

Hertel et. al. (2014) studied the conditions under which technological progress encourages cropland expansion. Chavas and Helmberger (1996) had argued that cropland expands if excess demand faced by producers in a country is price elastic. This is generally the case in small trading nations facing world prices, like Canada. Hertel et. al. (2014) argued that under this condition, the extent of land expansion depends on how scarce land is in that country as well as on available technologies. Land use decisions in countries that are more integrated with international markets have the potential to lead to increased extensification elsewhere. This is referred to as "leakage" or "slippage" (Lawley, 2019).

Villoria (2019) found that for the majority of countries he studied, domestic TFP growth was either uncorrelated or associated with cropland expansion (p. 870). It was only in a few developing countries, such as Asia and SSA where domestic TFP growth was associated with a land saving effect, due to being more insulated from world markets. For those countries with large commodity exporting sectors such as the U.S. and Canada, TFP growth is strongly associated with increased land expansion (Villoria, 2019, p. 884). Nevertheless, had TFP growth remained stagnant from 1961 to 2010, an estimated 173 Mha of additional global cropland, or one third of the Brazilian Amazon would have been needed to satisfy global food demand (Villoria, 2019, p.889). Hertel et. al. (2014) estimated that due to the Green Revolution, there was an 11% increase in global cropland area while real crop prices fell 29% (p. 13800). And while both yields and area expanded in Asia, Latin America and the Middle East, in the rest of the world, aggregate yields expanded but area remained essentially unchanged, resulting in a net reduction in area globally. These results underscore the importance of continued investment agricultural R&D as a strategy for reducing deforestation when demand for food is increasing and for payoffs from R&D investments for both global food security and environmental protection (Villoria et. Al. 2019, p. 871).

2.3 Intensification or Extensification: What is Better for the Environment?

Productivity growth does not just help address global food insecurity. It is also important for reducing the environmental impacts of agricultural production. As Garnett et. al. (2013) argue, it is important for "increasing food production on existing farmland in ways that place far less pressure on the environment while not undermining our capacity to continue producing food in the future" (p. 33). This is referred to as "sustainable intensification". A global initiative focusing on "sustainable productivity growth" supported by a coalition of countries has been launched to achieve this globally.[7]

Burney *et al* (2010) found that agricultural intensification during the Green Revolution avoided the release of about 161 Gt of carbon between 1961 and 2005 as crop production rose by 162% from a 135% increase in crop yields and a 27% increase in cropland expansion. They argued intensification is an important potential mitigation strategy for climate change, and future yield improvements and R&D investment should be prominent among efforts to reduce future GHG emissions. Burney et. al. 2010 concluded that ``the climatic impacts of historical agricultural intensification were preferable to those of a system with lower inputs that instead expanded cropland to meet global demand for food".

``The climatic impacts of historical agricultural intensification were preferable to those of a system with lower inputs that instead expanded cropland to meet global demand for food"

(Burney et. al. 2010)

Hertel et. al. (2014) also estimated the impact of the Green Revolution and TFP growth on the environment. They found that yield gains in agriculture since 1961 avoided emissions of about 161 Gt of Carbon (+104.2/-41.9 GtC) or an average of 3.6 GtC per year (p. 13799). They concluded that spatial variation is important for determining the relative impact of productivity increases on land use and environmental harm. This is because there are different pressures on land use in developing versus developed countries, as Villoria (2019) had found.

This regional variation also comes into play in Canada as well where productivity improvements and more intensive land use will have different environmental impacts depending on the region and the commodity in question as well as the source of those productivity improvements. As an example, more intensive precision agriculture and no-till practices in Western Canada have increased crop yields at the same time as GHG emissions have been reduced and more soil carbon has been sequestered. This compares to Eastern Canada where there has been less uptake of no-till practices but more cover crop adoption leading to less soil erosion and nitrogen leaching into waterways while land is being used more intensively. As Garnett et. al. (2013) argue in the context of "sustainable intensification", an increase in production does not mean that yields should increase everywhere or at any cost: the challenge is context and location specific. Rather, the merits of diverse approaches – conventional, organic etc. – should be rigorously tested and assessed taking biophysical and social contexts into account, requiring more research (p. 33).

At the same time, the impact of climate change on agricultural production will vary by region across Canada as well. Potentially longer growing seasons and higher temperatures may lead to higher yields in more northerly regions of Canada on the Prairies and in the boreal forest areas of Eastern Canada, while other regions will experience more extreme heat and flooding.

In summary, Coomes et. al. (2019) agree that increased global agricultural output since the 1990s has been largely driven by innovations that raised the efficiency of input use (land, labour, capital and other), defined as total factor productivity growth. However, there is a need to understand the underlying drivers of this TFP growth beyond technological approaches to how natural capital and ecosystem services play a role in order to improve sustainability and resilience outcomes of farming systems. This will require further research, better data and the will to use policies, such as taxes, subsidies and regulations to pursue the best combination of technological gains in agriculture along with broader societal goals (p. 27). Garnett et. al. (2013) complement this by suggesting that equally radical agendas will need to be pursed to reduce resource-intensive consumption and waste and to improve governance, efficiency and resilience (p. 34).

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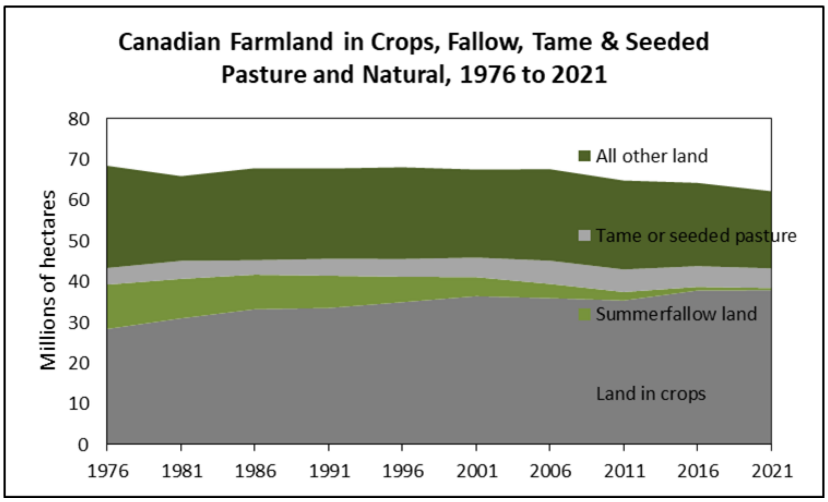
[7] The Sustainable Productivity Growth Coalition is described here: SPG Coalition Background | USDA

3. Canada's Place in the World

3.1 Canada is endowed with abundant arable land and water

While Canada's agricultural land accounts for only 7% of its total land area, 66% of this agricultural land was arable- under annual crops, fallow or meadows and pastures, with another 34% under permanent meadows and pastures in 2020 (FAO). Since 1961, Canada's agricultural land area declined from 61.8 Mha to 57.7 Mha in 2020, with major declines between 2000 and 2012 (FAO). The Census of Agriculture 2021 updated those statistics and reported that farmland area fell from 64.2 Mha in 2016 to 62.2 Mh in 2021(Figure 6). Significant declines took place between 2006 and 2011 and again between 2016 and 2021. While land in crops has increased over the past two censuses, tame and seeded pasture area declined since 2011 from 5.5 Mha to 4.8 Mha in 2021. In terms of farmland area, Alberta and Saskatchewan have the largest area and have managed to limit decline compared to other provinces. Ontario and British Columbia have experienced the largest average area declines.

Figure 6: Canadian Farmland in Crops, Tame and Seeded Pasture and Natural Land



Source: Statistics Canada, Census of Agriculture

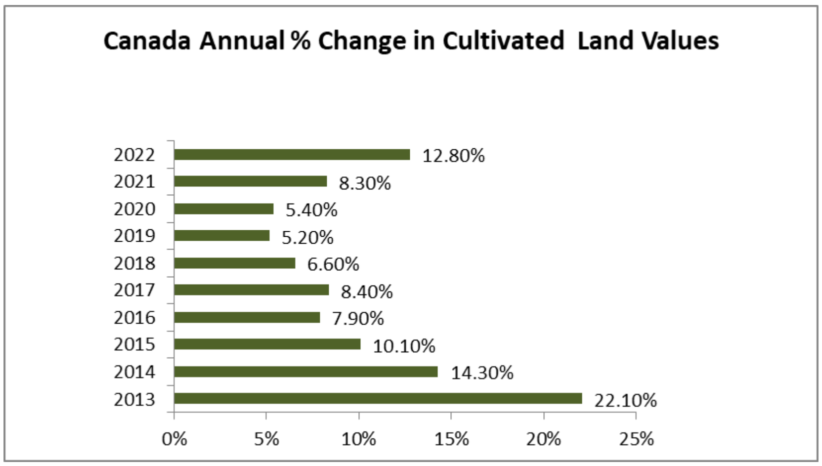
3.2 Canada is a major agri-food producer and one of a few net exporters of agri-food products, facing world prices

In 2022, Canada exported $91 B in products, as one of only a few net exporters in the world (Bilyea, T. 2023). Canada is also one of the top ten exporters of wheat, canola, pulse crops and pork and beef. With a trade-to-GDP ratio of 23%, Canada is highly integrated in international markets (OECD, Ag Monitoring, 2022, pg. 203). Being a small open economy, Canada faces world prices and hence was impacted by the sharp rise in world cereal and oilseed prices throughout 2021 and 2022 due to lower stock-to-use ratios and the Ukraine invasion in February 2022. A severe drought in Western Canada in the summer of 2021 reduced supplies of wheat and canola adding to pressures on prices. Livestock prices rebounded after the lows of 2020. This contributed to record high farm receipts in 2021 that exceeded expenses and net cash income rose to record levels in 2021 and 2022 at $ 17.5 B and $22.8 B respectively.

3.3 Higher Commodity Prices have boosted Land Values adding to Pressures on Land Use

Consistent with rising commodity prices and record farm income, land values in Canadian agriculture also increased, adding to pressures on land use. Other factors impacting land values include expected revenues, farm income, interest rates, government policies and zoning rules. Farm Credit Canada's (FCC) 2022 annual report on farmland values showed that the average value of cultivated Canadian farmland increased by 12.8% over 2021 (Figure 7) (FCC 2023). This is the largest annual increase recorded since 2014 and follows gains of 8.3% in 2021 and 5.4% in 2020. The largest increases took place in Ontario, Prince Edward Island and New Brunswick, with increases of 19.4%, 18.7% and 17.1%, respectively. Saskatchewan followed with a 14.2% increase. Even pastureland, which usually sells for less than cropland saw rising values in 2022: values rose in Manitoba (18.5%), Alberta (5.5%), British Columbia (3.7%) and Saskatchewan (2.8%), contributing to land use pressures.

Figure 7: FCC Land Values Change 2013 to 2022



Source: FCC Land Values in Canada 2022

In the 1990s, studies were done on the relationship between agricultural policy, farm income and agricultural asset values (i.e.farmland). Goodwin and Ortalo-Magné (1992) studied land values in six important wheat-producing regions in the U.S., Canada and France and found that there was a strong relationship between support through agricultural policies (measured by the OECD's the producer support equivalents (PSE)), and land values. This is because farm subsidies translate into higher returns to the holders of farm assets, reflecting the expectations of future returns.

4. Agricultural Policies, Farm Subsidies and how they Impact Land Use

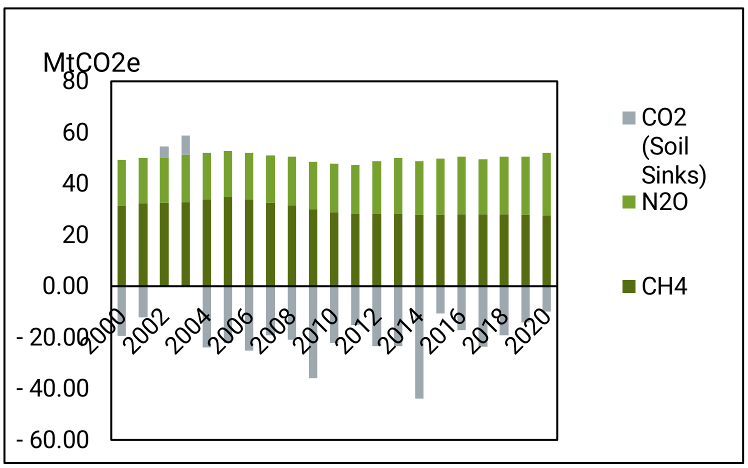
4.1 Canada's Business Risk Management Programs (BRM) and Land Intensification

Rude (2018) looked at the environmental impacts and land use implications of Canada's current suite of BRM programs. He argued that with government support, a producer may be encouraged to expand production and land use which could be harmful to the environment. The current suite of BRM programs includes *AgriInvest*, a savings-matching account, *AgriStability*, a deficiency payment triggered by a margin-based measure of whole farm income, *AgriInsure*, a production/crop insurance and *AgriRecovery*, a disaster assistance envelope. Rude argued that all of these programs provide payouts when current income is lower than a predetermined threshold, thereby creating the potential incentive to change production decisions (Rude, 2018. Pg. 3). However, because a voluntary individual margin approach has elements of both input and output subsidies that affect the bottom line, it is less likely that producers are able to predict payouts and "farm" the programs(Rude, pg. 4),consequently, the related environmental impacts are likely to be more modest. *AgriInves*t might have the potential to distort production decisions because producers could attempt to produce more and take more risks in order to increase their allowable net sales to receive the government matching funding. However, Rude found that market considerations dominate and the potential for *AgriInvest* to induce production and harm the environment is minimal. He argued none of the current suite of programs induces marginal and sensitive land into production either.

4.2 Canada's Climate Change Policies Affecting Agriculture

To ensure that land use intensification does not lead to increased GHG emissions and harmful environmental impacts, the Canadian and provincial governments have introduced policies and set targets to reduce these effects. Canadian agriculture emissions accounted for 8% of total Canadian emissions in 2020 and have remained relatively stable,at 69 $MtCO_2eq$ in 2020 (Figure 8). In 2021, Canada committed to reducing its national net GHG emissions by 40 – 45 percent below 2005 levels by 2030 and committed to achieving net-zero emissions by 2050 (ECCC, 2021), enshrined in the *Canadian Net-Zero Emissions Accountability Act* (2021, June). Canada also set national fertilizer emission reduction targets to reduce nitrous oxide (N2O) emissions by 30% below 2020 levels by 2030 and signed the Global Pledge to reduce economy-wide methane emissions by 2030. Provincial governments also set their own climate targets. Quebec's 2020-2030 Sustainable Agriculture Plan *(Plan d'agriculture durable 2020-2030)* aims to accelerate the adoption of efficient agri-environmental practices by 2030 as an example (OECD, 2022, Ag Monitoring, p.196).

Figure 8: GHG Emissions from Agriculture, 2000 to 2020



Source: ECCC, National Inventory Report 2022.

Canada's primary approach to reducing GHG emissions is through carbon pricing. While agricultural producers are exempt from the carbon tax on farm diesel and gasoline, they do pay the carbon tax on the energy they purchased for grain drying, heating of farm buildings, and indirectly on transportation and electricity embodied in inputs purchased and outbound transportation.

4.3 Canada's Agricultural Programs to Encourage More Sustainable Farm Practices

In July 2022, Federal -Provincial-Territorial (FPT) Ministers of Agriculture agreed in principle on the *Sustainable Canadian Agricultural Partnership* (SCAP) funding agreement covering the next five-year period (2023-2028).[8] This

[8] AAFC Press Release, July 22, 2022. Federal, Provincial and Territorial Ministers of Agriculture reach a new partnership agreement and inject new funds to support the sector - Canada.ca

new agreement, providing $3.5 B over 5 years, sets strong targets for reducing GHG emissions by 3-5 MT over the period, and aims to improve biodiversity and protect sensitive habitats as well as increase sector competitiveness, revenue and exports.

This is in addition to funding that had already been allocated to Canadian farmers to promote adoption of BMPs geared to improve soil health, water quality, livestock and nutrient use efficiency, productivity, soil sequestration and reduced GHGs. Cover cropping, rotational grazing, precision agriculture, 4R nutrient management and conservation tillage are just a few of the BMPS that have been identified as sustainable practices that will ensure Canadian farmers can reduce their environmental footprint, increase their resilience and produce more sustainable agri-food products to market to Canadians and customers around the world.[9]

Almost $600 million has already been allocated for BMP adoption. The $200-million On-Farm Climate Action Fund (OFCAF) is a three-year initiative to support farmers in adopting BMPs that store carbon and reduce GHGs, specifically in the areas of nitrogen management, cover cropping and rotational grazing practices.[10] Other activities support the adoption of BMPs, such as outreach, education and training. The Living Labs program is a $185 million, 10-year program that establishes a strong, Canada-wide network of living labs [11] where farmers, scientists, and other sector partners work together to co-develop, test and monitor BMPs on working farms to reduce Canada's environmental footprint. [12] Many provinces also have Environmental Farm Plan Programs (EFPs) that encourage farmers to adopt BMPs that reduce the environmental impact of agricultural production. [13] Producers use EFPs to assess the environmental risks on their farms and for knowledge sharing about regulatory requirements and BMPs.[14] However, all provinces differ in how they implement EFPs. In addition, the GOC recently finalized consultations on its Sustainable Agriculture Strategy (SAS) that will set a shared direction for collective action to improve environmental performance in the sector over the long-term, support farmers livelihoods and strengthen the business vitality of the Canadian agricultural industry.[15]

4.4 Farmers’ Behaviour and Practices that Impact the Environment and Land Use

The farm practices that Canadian farmers and ranchers adopt can influence both the productivity of their land and the environmental impacts of their production practices. In the trade-off between intensification and extensification, being able to produce “more with less”, while not expanding land use, will help meet the twin goals of producing enough food to feed the world while reducing environmental impacts.

Farm practices farmers adopt are influenced by factors such as their cost and profitability, the time it takes to learn about them, government policies, market forces, and technological advancements. Sustainable practices such as no-till farming, cover cropping, crop rotation, and nutrient management are some of the BMPs Canadian farmers have adopted to reduce the negative environmental impacts on their land. Many have also led to productivity increases, which ultimately lead to “sustainable intensification”.

Market forces, including consumer demand for sustainably produced products, can also motivate farmers to adopt environmentally responsible practices. Certification programs, such as organic farming or the Canadian Roundtable for Sustainable (CRSB) Certified beef program, grant market access and premium prices to farmers who adhere to specific environmental and productivity criteria. This market-driven approach incentivizes farmers

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9 Farmers for Climate Solutions analyzed the environmental benefits of these practices and made recommendations to the Government to support these practices. Available here: APF — Farmers for Climate Solutions

10 AAFC Press Release: Agricultural Climate Solutions – On-Farm Climate Action Fund - agriculture.canada.ca

11 AAFC, Agricultural Climate Solutions – Living Labs: The power of farms - agriculture.canada.ca

12 AAFC, Government of Canada launches nine new living labs: collaborative on-farm solutions to combat climate change in agriculture - Canada.ca

13 Background on the Environmental Farm Plans are discussed in CAPI, Research Report can be found here: 2022-06-15-CAPI-EFP-Report_EN.pdf (capi-icpa.ca)

14 CAPI, Policy Brief: Advancing EFPs. June 2022 pg. 3

15 Sustainable Agriculture Strategy - agriculture.canada.ca

to adopt sustainable practices that lead to the intensification of agriculture, without compromising environmental integrity.

5. Policy responses to ensure Long term Sustainable Land Use

Ensuring long-term sustainable land use in agriculture is a critical policy objective, given the sector's importance to the economy and for the environment. One critical consideration is the need for a balanced approach that addresses the needs of both farmers and the environment. This can be achieved by promoting sustainable agriculture practices and conservation of natural resources, protecting farmland from development, providing sustainable funding, and raising awareness among stakeholders. Moreover, policymakers must also consider the trade-offs between short-term economic gains and long-term environmental sustainability. Policies that prioritize the former, such as subsidies for unsustainable practices or development on farmland, can have long-term negative consequences for the environment. Canada can learn from international experience on the most effective way to balance these trade-offs.

5.1 International Case Studies

5.1.1 The European Union

Europe has the highest proportion of land (up to 80 %) used for settlement, production systems (in particular agriculture and forestry) and infrastructure. Conflicting land-use demands often arise, requiring decisions that involve hard trade-offs. Land use change in Europe is influenced by various factors, such as the production of food and fiber, bioenergy, biomass, carbon storage in land and soil, transportation infrastructure, and the growing need for housing and living space per person. Economic activity and the development of transport infrastructure also contribute to land use. However, land is a limited resource, and its utilization plays a crucial role in environmental change, affecting ecosystems, quality of life, and the management of green infrastructure.

Across EU member states, decisions on land-use planning and management are usually made at the local or regional level. This includes urban planning, as well as agricultural and forestry practices. However, it is the European Commission's responsibility to ensure that environmental concerns are taken into account by Member States in their land-use development plans and that integrated land management practices are followed. Policies on climate change adaptation by the European Union are relevant to current and future land-use practices and the economic sectors that depend on them. Land use also plays a significant role in other policy areas, including territorial cohesion, transport, the climate and energy framework, and nature and biodiversity conservation.

The EU has several policies and regulations that are relevant to land use and can influence intensification or extensification. Some of these include:

1. Common Agricultural Policy (CAP) : The CAP provides financial support to farmers and promotes sustainable farming practices. Historically, the policy has been the driving force in the EU behind agricultural intensification (Donald et. al, 2002) through subsidies for increased production and the use of agrochemicals. However, the shift towards promoting extensification in the CAP has been ongoing for several years, with the new focus areas being reflected in the updated policy for 2023- 2027 (The Common Agricultural Policy:2023-2027). This policy, as part of the EU Green Deal includes the Farm to Fork and the Biodiversity Strategies. These policies include targets for reducing the use of pesticides and fertilizers, increasing the areas of organic farming and improving welfare which impact land extensification. The new CAP includes several measures that promote extensification, such as eco-schemes, which provide financial incentives to farmers who adopt environmentally-friendly practices, and the requirement for member states to dedicate at least 25% of their direct payments' budget to eco-schemes (European Commission, 2021).

   Following the outbreak of war in Ukraine, the European Commission proposed a series of short and medium-term relaxations to CAP's environmental commitments to offset expected shortages in grain imports and enhance food security. This relaxation may lead to the cultivation of fallow lands for livestock farming, which would increase environmental damage, biodiversity loss, and public health risks. Furthermore, the loss of semi-natural habitats in arable systems, including fallow lands, would negatively impact arthropod functional diversity and the ecosystem services it supports, which could affect agricultural production (Morales et. al. 2022).

2. Water Framework Directive (WFD): The WFD is an EU policy that aims to achieve good water quality across Europe. It has implications for land use as it requires member states to manage land in a way that protects water resources, such as rivers, lakes, and groundwater (Giakoumis & Voulvoulis, 2018; European Commission; Water Framework Directive).

3. Land Use, Land Use Change and Forestry (LULUCF, 2018) – EU regulation that was adopted in 2018 and sets out rules for accounting for GHG emissions and removals in the land use, land use change and forestry sector in the EU. The implementation of the LULUCF regulation has significant implications for agricultural land use. The regulation provides the incentivize for the implementation of sustainable land management practices that promote carbon sequestration and reduce GHGs including reduced tillage, cover cropping, and crop rotation. The regulation also imposes limits on the use of forests and other natural lands for bioenergy production, which could indirectly affect agricultural land use by increasing demand for agricultural crops used for bioenergy production. By incentivizing afforestation and sustainable forest management, the regulation can influence extensification of land use in some cases. On the other hand, by discouraging conversion of forests and other land use types to other land uses, the regulation can influence the intensification of land use already under cultivation or development.

5.1.2 The United States

Agricultural land use is influenced by policy in the United States, as the federal and state governments implement various programs to promote sustainable land use. These policies aim to address issues such as soil erosion, water quality, and biodiversity loss while also ensuring the long-term viability of the farming industry.

At the federal level, the USDA is responsible for implementing policies related to agricultural land use. The USDA offers a range of programs to promote sustainable land use practices, including the Conservation Reserve Program (CRP), Agricultural Conservation Easement Program (ACEP), Environmental Quality Incentives Program (EQIP), and the Sustainable Agriculture Research and Education (SARE) program, among others (USDA, n.d.).

1. The CRP is a voluntary program that pays farmers to take environmentally sensitive land out of production and plant cover crops or trees. This helps to prevent soil erosion and improve water quality, among other environmental benefits.
2. The ACEP provides long term or permanent easements for preservation of wetlands and the protection of agricultural land (cropland, grazing land, etc.) from commercial or residential development.
3. The EQIP provides financial assistance to farmers who adopt or install conservation practices on land in agricultural production.
4. The SARE program supports research and education projects that promote sustainable farming practices, including those related to soil health, water conservation, and pest management.

Many states have developed their own programs to promote sustainable land use in agriculture. For instance, California's Agricultural Lands Conservation Program (SALCP) provides funding to prevent the conversion of farmland to non-agricultural uses while the Vermont Working Land Enterprise Initiative offers grants to supporting working lands, which includes agriculture and forestry.

The United States also recently invested significant amounts in Climate Action for farmers as part of the Inflation Reduction Act (IRA)'s $369 B for climate change. This bill will make historic investments to ensure that rural communities are at the forefront of climate solutions. The investments affirm the central role of agricultural producers and forest landowners in climate solutions by investing in climate smart agriculture, forest restoration and land conservation. It also makes significant investments in clean energy development in rural communities.

- More than $20B to support climate-smart agriculture practices.
- $5 B in grants to support healthy, fire resilient forests, forest conservation and urban tree planting.
- Tax credits and grants to support the domestic production of biofuels, and to build the infrastructure needed for sustainable aviation fuel and other biofuels.
- $2.6 B in grants to conserve and restore coastal habitats and protect communities that depend on those habitats[16]

5.2 What we can learn from International Experience

While Canada has implemented various policies and programs aimed at promoting sustainable farm practices in agriculture, there are still lessons that can be learned from international experience and approaches. First of all, Canada could benefit from other countries' experience integrating different policy instruments into a comprehensive policy framework that promotes sustainable land use practices in agriculture, such as the UK's Environmental Improvement Plan (2023) which links its Food Strategy to efforts to preserve nature and land use for future food production.[17] The EU's Farm to Fork Strategy and Common Agricultural Policy (CAP) is an integrated approach, but focuses on "extensification" rather than "intensification" by promoting long term sustainable land use, conservation of natural resources, protected areas and environmental performance while also setting significant reduction targets on fertilizer, pesticide and antibiotic use. The result appears to be leading towards reduced EU food production, protracted concerns among farmers being forced to exit (with compensation), carbon leakage as food production is being shifted to higher carbon intensive countries and global food security concerns. (USDA-ERS, 2021). Instead, the U.S.'s Climate Smart programs under the U.S. Inflation Reduction Act (2022) tend to be less prescriptive and provide more incentives and flexibility to spur more sustainable production practices that are also innovative solutions.

Canada could learn from other countries' regulatory frameworks that promote sustainable land use in agriculture and incentivize farmers to adopt sustainable practices. Canada can also benefit from education programs like the Sustainable Agriculture Research and Education program in the USA and the Horizon 2020 research and innovation program in the EU, which provide funding for research and education programs that promote sustainable farming practices.

Furthermore, Canada should learn from the EU's difficulties in implementing cross-compliance requirements to promote sustainable land use practices and adapt alternative approaches. Cross-compliance requirements link the receipt of direct payments to farmers with environmental and social standards and have periodically been suggested. In 2013, the EU introduced "greening" payments which were conditional on undertaking practices that would benefit the environment under CAP, including crop diversification for soil health, maintenance of permanent grassland for biodiversity and carbon sequestration, and maintaining land with specific characteristics or "ecological focus areas" to improve biodiversity. When the "greening " program was evaluated by the EU Court of Auditors in 2017, they concluded that it fell short of benefiting the environment and climate because it did not clearly define its targets for achieving EU soil, climate and biodiversity improvements due to lack of data, ineffective targeting (crop diversification vs. rotation), overly generous payments and high complexity.[18] As a result, only 5% of EU farmland saw changes in farming practices that would benefit the environment.

Two recent CAPI studies - Rude (2018) and Mussell and McCann (2022) argue that alternative policy approaches should be found instead to boost environmental performance. This is because Canada mostly has demand-

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[16] FACT SHEET: How the Inflation Reduction Act Helps Rural Communities | The White House

[17] Environmental Improvement Plan (publishing.service.gov.uk)

[18] EU Court of Auditors, "Greening: A More Complex Income Support Scheme, Not Yet Environmentally Effective," Dec. 2017. Accessed at: SR_GREENING_EN.pdf (europa.eu)

driven farm income stabilization programs rather than entitlement programs to which cross-compliance conditions can be attached. Instead, targeted environmental programs and leveraging Environmental Farm Plans (EFPs), would likely deliver better, more efficient and effective environmental outcomes. In fact, under the new FPT 5- year agreement (SCAP), a pilot program has been launched linking *Agri-Invest* payments to EFPs (AAFC. July 22, 2022. Backgrounder).

The U.S.'s experience with cross- compliance has been more successful. Baylis et. al. (2008) argue that compared to the EU, the U.S. agri-environmental and conservation programs tend to be focussed on more easily measured targets, while the EU programs are targeted toward multiple goals (Baylis et. al. 2008). Since the degree of targeting can determine how well a program meets its objectives, evidence suggests that the US environmental programs are more effective than the EU ones at achieving their goals. Another difference is that agri-environmental policy in the EU focuses on externalities that are by-products of the intensification of farming – i.e. the use of too many non-land inputs per unit of land (i.e. fertilizer), whereas U.S policy targets the by-products of extensification- i.e the use of excessive amounts of environmentally sensitive land. (Baylis p. 762). Hence Canada can learn from the U.S. experience as well.

To conclude, by adopting policies that provide financial incentives and technical assistance to farmers, developing regulatory frameworks that promote sustainable land use, promoting education and awareness-raising campaigns, and learning from the different policy mechanisms used by these countries, Canada can ensure the long-term sustainability of the agricultural sector while protecting the environment.

6. Conclusions

In the last 60 years, global shifts in land use have brought about marked changes. Total agricultural land (permanent pastures, land producing permanent crops, and crop land) has declined; however, within this decline, cropland area has expanded, and pasture area has experienced a steeper decline. These trends confront an increasing global population, rising incomes, and growing demands for food- especially protein. The race to decouple economic development from fossil fuels and the associated emissions and global warming effects has driven countries toward increasing substitution of biofuels/biodiesel for fossil fuels. The situation presents a stark reality- the world must generate more calories, protein and renewable fuels, and the means of doing so are limited.

The essential question is how best to do this. Agricultural production can be increased by converting land from other uses into agriculture (extensification) or, alternatively, increase production by more intensively using the existing land base (intensification). These two alternatives are not equivalent, particularly in terms of the implied boundaries to the system. Extensification views the boundaries primarily as an output constraint (how many people must we feed), while intensification views the boundaries as being available land constraints, with the output generated given this constraint. These are not equivalent.

The literature cited in this paper highlights the constraints on available land for agriculture, and the prospect for harm from extensification (habitat and biodiversity lost, episodic GHG emissions, etc.). It also highlights the prospect that intensification here can lead to extensification elsewhere, with the evidence in developing countries (notably Africa). Implicit in the discussion of the advantages of intensification is that its effects can be appropriately managed- with offsite effects contained (e.g. leaching; surface runoff; pest resistance; etc.). Moreover, it implies the need for ongoing renewal of agricultural technologies- as some technologies fail or generate unanticipated/undesirable side effects. In turn, this implies an ongoing commitment of resources- to R&D and new technologies; to meaningful monitoring of offsite effects from existing technologies; to effective evidence-based approval and appropriate liability protection for new technologies, and to effective science and risk communications.

The above components apply to agricultural systems generally, but there are some more uniquely Canadian observations that apply. One relates to increasing farmland values that are driven by a range of factors- such as farmer expectations, increasing farm prices, and the effects of certain farm subsidies. Conversely, land values both increase due to intensification (among other factors) and, in turn, increasing land values themselves stimulate intensification to generate economic returns. The prospect that ever- increasing economic land values push agriculture further toward the unintended offsite effects listed above should be a matter for concern and for monitoring.

Secondly, with a warming climate, some regions in Canada and for some crops, areas may become newly feasible for agricultural production and present opportunities, while elsewhere in the world warming generates decreases in yields and makes agriculture more difficult and less efficient. This may present the prospect that new land move into agriculture in Canada and that land in excessively warming regions in agriculture revert back to a pristine state. The net effect would be an increase in efficiency, not at odds with the general notion of benefit to intensification. However, the policy framework to rationalize or realize this does not currently exist. The paradigm of intensification versus extensification in agriculture is thus a complex paradigm, with important ongoing considerations that project across a range of parameters.

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