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Scaling Natural Climate Solutions in Agriculture: A Review of Canada's Approach and Pathways Forward

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Abstract

Scaling natural climate solutions in agriculture is increasingly being explored as a critical vector to achieve national net-zero targets. The adoption of natural climate solutions by agricultural producers, such as cover crops and avoided grassland conversion can contribute to climate change mitigation, while also producing social, environmental, and economic co-benefits. Despite the upswing in interest to position agriculture as a solutions provider to climate change, existing national greenhouse gas mitigation policies in agricultural sectors fall short of the action needed on a global scale to contribute to keeping global warming below 2 degrees Celsius.

Here, the governance ecosystem that influences natural climate solutions in Canada's agricultural sector is outlined. This governance ecosystem is diverse and growing, but uncoordinated. Within this ecosystem there are a variety of governance mechanisms led by government, industry, and civil society actors and combinations among the three. While successes are observed in current efforts to foster partnerships, fund projects, and advance regional on-farm research and innovation, there are a few key limitations. Moving forward, there are emerging governance mechanisms that have the potential to improve coordination among actors such as greenhouse gas emission targets within the agricultural sector. Canada also has an opportunity to look abroad and learn from other countries' approaches to developing innovative programs and sector-specific strategies to scaling natural climate solutions. Recognizing that a comprehensive review of the governance ecosystem that influences natural climate solutions in Canadian agriculture is lacking, this report, in part, addresses this gap. Developing a deeper understanding of the present situation can inform emerging governance mechanisms to effectively build upon current efforts and work to address existing barriers and gaps.

1. Introduction

Natural climate solutions (NCS) are actions that result in contributions to climate change mitigation. These actions include improved management, restoration and protection of forests, grasslands, croplands, and wetlands (Drever et al., 2021). They also produce co-benefits that can contribute to economic, environmental and societal goals such as enhanced biodiversity and sustainable rural communities (Seddon et al., 2019a). Agriculture has emerged as a key sector that can make an important contribution to Canada's 2050 net-zero target by enhancing NCS, such as cover cropping and improved nutrient management (ECCC, 2020). However, the sector is currently underachieving its full potential in providing solutions to climate change mitigation. Seventy-three megatonnes (Mt) of carbon dioxide equivalent (CO₂eq), or approximately 10 percent of Canada's total GHG emissions originated from its agricultural sector in 2019 (ECCC, 2021b). These emissions are projected to increase to 74 Mt CO₂eq by 2030 (ECCC, 2021a). Concurrently, the combination of carbon sinks from forestry and other land uses, along with widespread implementation of NCS across natural ecosystems, and the proposed measures to reduce emissions from fertilizer use in agriculture are estimated to reduce national emissions by 27 Mt CO₂eq by 2030 (ECCC, 2021a). These projections and the increasing demand to advance innovative climate solutions in agriculture signal a strong need for government, industry and civil society to foster an enabling, coherent governance ecosystem that encourages the adoption of NCS.

In contemporary environmental governance, the state is not the only actor capable of leading the charge on an issue. While civil society and industry are not just alternative regulators or complementary actors to the state; instead, they are integral to effective governance (Steurer, 2013). Within an environmental governance ecosystem, there are often multiple actors and partnerships between actors that implement governance mechanism to promote action such as incentive programs, certifications, and education and outreach initiatives that can be leveraged at different scales (Paehlke, 2001;

Armitage et al., 2012; Steurer, 2013). While multi-actor governance approaches may resemble a complex web of actors and their associated governance mechanisms, it does not necessarily equate to a less effective approach compared to linear models of governance and authority. Exploring the potential of multi-actor and mixed forms of governance that exist within diverse governance ecosystems is necessary according to Nilsson and Persson (2012). They explain this is because the interactions between Earth systems and complex issues, such as agriculture's impacts on climate change appear to be ungovernable via singular, command and control governance approaches. In the context of NCS in agriculture, Nilsson and Persson's (2012) conclusion resonates as diverse, yet, complementary governance mechanisms is emphasized as a key condition to develop an enabling governance ecosystem (IPCC, 2019). Furthermore, the breadth of actors from different levels of government, along supply chains, and within civil society that have an interest in scaling NCS in agriculture, underlines the importance of looking at the diverse governance ecosystems through multi-actor governance approaches that can effectively capture these diverse actors and their influences and interactions.

Today, there is a surge in effort to transform agricultural producers into climate solution providers. New governance mechanisms and existing ones are rapidly being introduced and repurposed to encourage widespread NCS. Parallel to this activity, is the expansion and development of research on fundamental questions that influence the governance of NCS in agriculture. This includes evaluating the scale and capacity of agriculture to contribute to climate change mitigation, the social cost of carbon, and best approaches to effectively integrate agriculture within climate policy portfolios without undermining productivity and food security objectives (Paustian et al., 2019; Leahy et al., 2020; Lynch et al., 2021). The growing and diversifying arena of enablers for climate change mitigation in agriculture can be characterized by an increase in reports on financing agriculture-based NCS (e.g., USFRA, 2021), expansion

of cost-share programs that explicitly fund climate action, a growing regenerative agriculture movement, increasing carbon neutrality announcements from companies in the agricultural sector, and a rise in carbon focused certifications, initiatives, roundtables, coalitions and platforms. Scaling NCS research and technology is, in part, dependent on these enablers to fund and validate their utility (Lin et al., 2017; Paustian, 2019; Smith, 2018). Due to the rapid growth in activity that seeks to encourage and understand NCS, many experts advocate for governance mechanisms with strong evidence-based foundations coupled with adaptive management approaches (OECD, 2019; Henderson et al., 2020). This approach can better position actors to encourage NCS that are based on the best available science and be flexible enough to adapt as our knowledge and ecosystems evolve (Lynch et al., 2021; Seddon et al., 2019b).

Despite the upswing in activity, existing national GHG mitigation policies in agricultural sectors fall short of the action needed on a global scale to contribute to keeping global warming below 2 degrees Celsius (Henderson et al., 2020; Hönle et al., 2019). These shortcomings may be a result of the historic reluctance to integrate agriculture within national GHG efforts and targets (Leahy et al., 2020). Alternatively, excluding agriculture from national GHG mitigation targets pushes milestones further out of reach, increases the cost of mitigation for other sectors, and hinders innovation, collaboration and the scalability of climate change mitigation in agriculture (Chabbi et al., 2017; Wollenburg et al., 2018). In response, experts advocate for approaches that take agriculture off the margins in climate policy and promote coherency and scientific rigor as key principles to guide its integration (Wilke et al., 2013;

OECD, 2019; Henderson et al., 2020; Lynch et al., 2021). Along with targets, other key recommendations to scale NCS in agriculture include creating incentives such as market signals for NCS, establishing monitoring systems to measure NCS adoption rates and impacts, and enrolling agricultural producers in decision making processes. These recommendations come from the expanding body of research on the governance of NCS and are developed in response to the growing recognition that action is needed to create an enabling governance ecosystem to effectively scale NCS in agriculture (Hönle et al., 2019; Lankoski et al., 2018; Leahy et al., 2020).

Recognizing that a comprehensive review of the governance ecosystem that influences NCS in Canadian agriculture is lacking, this report, in part, addresses this gap. This information can inform emerging governance mechanisms such as those recently proposed by the Government of Canada in the Federal Budget (e.g., further support for the Agricultural Climate Solutions program) to effectively build upon current efforts and mitigate barriers. This report starts with a brief overview of NCS in agriculture, followed by an outline of the process to developing an inventory of governance mechanisms that influence NCS adoption in Canada's agricultural sector. Next, a summary of these existing governance mechanisms is shared along with a brief evaluation of Canada's approach. Finally, a discussion on potential pathways to enhance NCS in Canadian agriculture and highlights of other country's approaches is presented.

2. Natural Climate Solutions in Agriculture

In agriculture there are a variety of terms that describe a similar suite of best management practices (BMP) but have different objectives, including NCS, soil health practices, and regenerative agriculture. Globally, governments, companies, organizations and academics have worked to define and advance the implementation of BMPs in agriculture. This work has led to rich discourse and debate on defining sustainable agricultural production and its impacts on the environment (e.g., Paustian et al. (2020) response to Ranganathan et al., (2020)). First, it is important to recognize that many practices that are categorized as NCS such as cover cropping and nutrient management were not initially introduced as 'solutions to climate change' (Asgedom and Kebreab, 2011; McAllister et al., 2011). Many BMP were first promoted in conventional agricultural systems to achieve other environmental and/or productivity outcomes such as minimizing nutrient run-off in neighboring waterways (Lal, 2015).

As we have come to learn more about the various effects of adopting BMP, NCS has emerged as a subset that describes those that enhance agriculture's capacity to mitigate climate change and produce economic, social and environmental co-benefits (Griscom et al. 2017; Drever et al., 2021). NCS in agriculture includes preserving grasslands, grazing optimization, converting marginal lands to tree cover or perennials, and adopting practices on cultivated land such as no-till, cover cropping, and improved nutrient management (Griscom et al., 2017). Co-benefits from NCS are inclusive of those that produce positive outcomes for biodiversity, soil (e.g., improved soil fertility from biochar), water, and society (e.g., conservation of culturally important ecosystems from avoided grassland conversion). Table 1 outlines examples of NCS, describes how they contribute to GHG reductions, and the potential co-benefits they can produce.

Table 1. Examples of Natural Climate Solutions in Agriculture.

Natural Climate Solutions	Description	Co-benefits
Cover crops	<ul style="list-style-type: none"> Cover crops are crops grown to provide additional plant cover in late summer-fall with or after the cash crop, in early spring before planting the cash crop, or on fallow areas Adds to soil carbon sequestration and in the case of legumes, cover crops can reduce the need for nitrogen fertilizer 	Air, biodiversity, Soil, Water, Social
Biochar (crop residue)	<ul style="list-style-type: none"> Biochar is a nutrient application made from crop residue that is turned into charcoal through pyrolysis Adds to soil carbon sequestration 	Soil, Water
Nutrient management	<ul style="list-style-type: none"> Improved nutrient management includes the adoption of the "4R" (right source, right rate, right time, and right place) of nitrogen fertilizer use Reduces and avoids nitrous oxide emissions from nutrient application and upstream emissions from fertilizer production 	Air, Biodiversity, Water
Grazing optimization	<ul style="list-style-type: none"> Matches stocking rates to carry capacity of pastures and grasslands to maximize forage and livestock production Adds to soil carbon sequestration 	Biodiversity, Water, Soil
Avoid grassland conversion	<ul style="list-style-type: none"> Avoids grasslands being converted to other uses such as cropland or urban development Avoids losses of carbon storage in grasslands 	Air, Biodiversity, Soil, Water, Social

Sources: Griscom et al., 2017; Fargione et al., 2018; Drever et al., 2021

Enhancing the co-benefits from NCS is a critical component in scaling NCS adoption and maximizing outcomes. To enable NCS to effectively produce co-benefits, NCS projects should be grounded by systems approaches that recognize the complexity of ecosystems and account for the diverse objectives of stakeholders involved (Seddon et al., 2019a). Blindly investing in climate change mitigation projects that do not demonstrate co-benefits in ecosystem health and local communities can undermine the Sustainable Development Goals (SDGs) and limit the sustainability of climate action (Chabbi et al., 2017; Norton et al., 2020; Seddon et al., 2019b). To mitigate this potential harm, for example, NCS programs that encourage tree planting or the expansion of grasslands on marginal land should recommend species that are native or compatible with the local environment, promote economic opportunities for local actors, and seek to minimize externalities such as albedo effects (Griscom et al., 2017; Norton et al., 2020). While the focus of NCS is mitigating climate change through nature, the co-benefits and potential trade-offs of actions must also be at the forefront of decision-making and governance mechanism design (Brady et al., 2019; Monahan et al., 2020; Seddon et al., 2019b).

3. Methods

The governance ecosystem that influences NCS in Canada's agricultural sector was identified through an environmental scan of websites, grey literature and select academic literature that describe and examine existing governance mechanisms. Drawing on a model of multi-actor governance from Steurer (2013), these various governance mechanisms are visually organized according to their primary architects, be they governmental, industry, civil society, or some combination of these (see Figure 1).

The scan included the websites of the governance mechanisms (e.g., Alberta Offset Systems homepage) to collect basic information on the characteristics of governance mechanisms and possibly reports

that outline progress. The environmental scan also included information from other forms of grey literature such as external reports on the impacts of a governance mechanism and its perceived effectiveness. Peer-reviewed literature that examines governance mechanisms that encourage NCS adoption was included to collect information that contextualized perceived drivers of effectiveness, perceived barriers, and co-benefits (e.g., Hurlbert, 2014; Swallow and Goddard, 2013). Lastly, popular literature was scanned as a means to better understand the discourse surrounding each governance mechanism and to identify connections between key actors involved.

4. Results

In Canada, there are a variety of governance mechanisms that directly influence NCS adoption as well as those that indirectly influence NCS adoption but have broader or complementary objectives such as soil health and sector innovation. Government, industry and civil society actors can also influence each other's capacity to engage in NCS. This review is conducted at a time when different levels of government are announcing greater commitments to climate action in agriculture and as the governance ecosystem that influences NCS in agriculture is rapidly growing and diversifying (e.g., ECCC, 2020; Government of Quebec, 2020).

After compiling and reviewing the ecosystem of governance mechanisms that influence NCS in Canada's agricultural sector, it appears that Canada's approach to scaling NCS is diverse and growing, but uncoordinated. While this approach has produced successes in fostering partnerships, funding NCS projects, and advancing on-farm research and innovation, there are a few key limitations. A lack of coordination within a governance ecosystem can create challenges such as inconsistencies, duplications and even contradictions between actors and governance mechanisms (Brady et al., 2019). Recognizing that Canada is a federation

with a diverse agricultural sector, coherency across the country may be challenging to achieve due to jurisdictional and authority dynamics. Nonetheless, coherency is achievable among diverse actors in environmental governance when there is a focus on coordinating action to drive and scale impact (Ostrom, 2010; Armitage et al., 2012; Streurer, 2013). To enable this coordination, experts are increasingly advocating for systems approaches to developing governance mechanisms that aim to contribute to

climate change mitigation within the agricultural sector (e.g., Smith, 2018) Furthermore, while acknowledging soil health or regenerative agriculture initiatives may not directly align on all objectives of an NCS initiative, they often promote similar practices and agricultural systems, and therefore present an opportunity for deeper coordination across the sustainable agriculture spectrum to maximize collective capacity and minimize inefficient uses of resources.

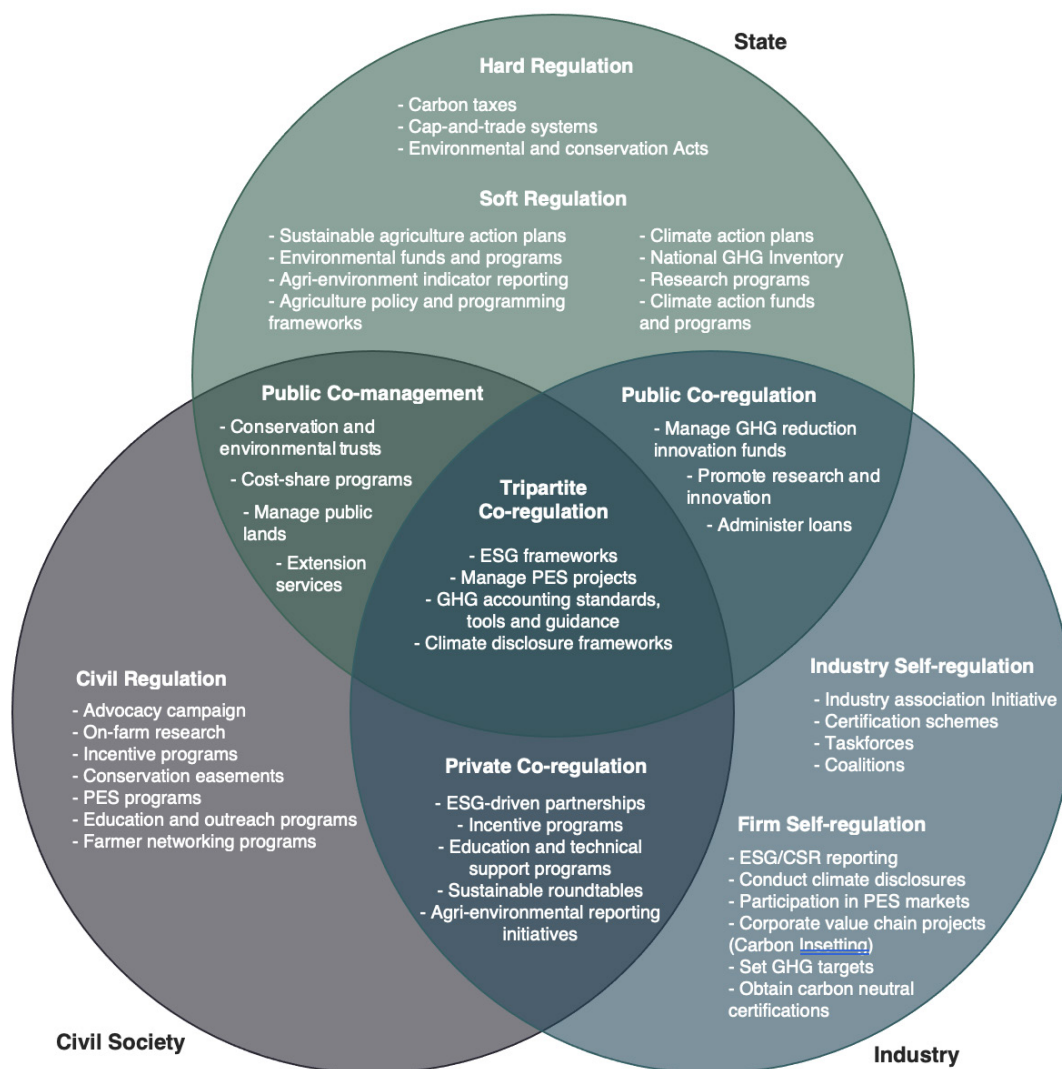


Figure 1. Governance mechanisms that influence NCS adoption in Canada's agricultural sector. This figure utilizes Steurer's (2013) governance model of 'who regulates' to visually organize the governance ecosystem that influences NCS in Canada's agricultural sector. The content within the Venn Diagram describes existing governance mechanism types that influence NCS adoption in Canada's agricultural sector. For further information on the type of regulations and their associated governance mechanisms see Appendix A.

4.1. State-led policy frameworks, programs and markets

Policies and programs led by governments in Canada that influence NCS adoption in the agricultural sector are steered and funded through two key policy frameworks: (1) the Canadian Agriculture Partnership (CAP); and (2) the Pan-Canadian Framework on Clean Growth and Climate Change, which was recently built upon by A Healthy Environment and a Healthy Economy – Canada’s strengthened climate plan. The CAP is a three billion dollar federal, provincial and territory investment in the agricultural sector over 5 years (current period 2018 – 2023) (AAFC, n.d.). Programs funded under CAP that directly encourage NCS are primarily cost-share programs for improvements in on-farm efficiency and adoption of BMPs. The CAP also funds programs that focus on advancing research, innovation and product development. In Ontario for example, the On-Farm Applied Research and Monitoring (ONFARM) program facilitates monitoring and modelling of priority watersheds of a previous cost-share program, establishes on-farm trials to test the effectiveness of BMP, and fosters a network among stakeholders and producers to advance on-farm research (OSCIA, n.d.). While this research program has a soil health focus, many of the practices tested, including cover crops are also NCS, underlining the potential of existing initiatives to be an entry point to leverage the promotion and measurement of GHG reductions on-farms.

The governance mechanisms proposed in A Healthy Environment and a Healthy Economy to influence NCS adoption in agriculture are starting to rollout. In particular, the Agricultural Climate Solutions program is investing \$185 million over 10 years to implement NCS in agriculture (ECCC, 2020; AAFC, 2021). Other important governance mechanisms outlined within the climate action plan include a proposed national GHG emission reduction target of 30 percent below 2020 levels from fertilizers. Provincially, Quebec recently launched their 2020 – 2030 Sustainable Agriculture Plan. This plan puts Quebec on a path of transitioning to sustainable

and regenerative agricultural systems with reduced GHG emissions from production and enhanced soil cover and soil organic matter content. Quebec’s 2020 – 2030 Sustainable Agriculture Plan is inclusive of a \$125 million investment over the first 5 years and has a specific on-the-ground focus with knowledge development, knowledge transfer, and training at the forefront (Government of Quebec, 2020). According to the Government of Quebec, the targets within this plan are aligned with the province’s climate action plan, 2030 Plan for a Green Economy. While these climate action plans are in their early stages of implementation, they underline the role that governments can play in providing direction for climate change mitigation efforts.

In Canada, compliance carbon markets that have offset protocols for producers to receive carbon credits through are operating in Alberta and Quebec. In compliance carbon markets, heavy emitters have a regulated allowance on their GHG emissions and one way to stay below their allowance is to purchase offset credits from sectors that can avoid or capture GHG emissions such as agriculture. Most noteworthy, producers in Alberta have been successfully enrolled in projects under protocols such as the conservation cropping protocol where producers receive carbon credits for reduced tillage. Other protocols for agriculture on the Alberta Offset System have not experienced the same up take, including the Nitrous Oxide Emission Reduction Protocol (NERP), which has gone through multiple attempts to make it operational, with limited success so far. In Quebec, while no projects have been developed to-date, producers are currently eligible for carbon credits to develop covered manure storage facilities with methane destruction (e.g., implementing anaerobic digesters). To expand Quebec’s supply of offsets, the province is also currently analyzing the feasibility and relevance of a number of other protocols including the development of its own NERP protocol (Government of Quebec, n.d.).

4.2. Industry-led value chain initiatives and market incentives

Industry actors are increasingly involved in the governance of NCS in agriculture. This involvement is a result of multiple drivers, including a global shift towards sustainable investment that is intensifying the demand for companies to engage in climate action. The demand for industry-driven climate action is also advancing a global movement of company's setting GHG targets that align with the goals of the Paris Agreement (SBTi, n.d.). This demand is complemented by a recognition in the private sector that climate action is necessary and can be good for business (SBTi, n.d.). Setting GHG targets and engaging in the transition to a low-carbon economy can benefit businesses' by reducing vulnerability to climate risks, improving operational efficiency, and fostering a competitive advantage in the context of Environmental Social and Governance (ESG) investment. In some cases, company-led climate action can also provide new opportunities for revenue generation (e.g., engaging in the sale of carbon credits) and product marketing (e.g., carbon neutrality certifications) (Walenta, 2018; SBTi, n.d.). The governance mechanisms that facilitate climate action by industry actors include voluntary carbon markets, carbon neutral certifications schemes, and ESG reporting standards and guidelines.

For many agri-food companies and agribusinesses, setting GHG targets translates to a significant amount of GHG reductions required along their value chain that are outside of their direct operations (e.g., farm-level GHG emissions). These emissions are described as a company's Scope 3 emissions (GHG Protocol, 2011). To mitigate Scope 3 emissions to meet GHG targets, many companies are beginning to facilitate the adoption, measurement and verification of NCS in agriculture such as General Mills through their One-Million Acre initiative and Nutrien through their pilot project, Carbon Program. Complementary to reducing GHG emissions along value chains, companies are also seeking out offset projects on voluntary carbon markets to meet GHG targets (e.g., Shopify's Evergreen Offset Portfolio). Voluntary

markets are usually separate from compliance markets but can be made complementary and can even be integrated (TSVCM, 2021). For example, voluntary markets can be a place to incubate novel offset protocols before they are considered by compliance markets and they are advancing best practices in developing NCS offset projects that compliance markets can draw from (WEF, 2021). In the global voluntary market space, Canadian agriculture has access to protocols that can enable the development of offset projects. These include the Canada Grasslands protocol on the Climate Action Reserve's (CAR) voluntary market registry and the Improved Agricultural Land Management protocol in the Verified Carbon Standard's program (Ashton and Esmail, 2021).

Markets that facilitate payment for multiple ecosystem services (e.g., Ecosystem Services Market Consortium in the United States) have not been developed on a large scale in Canada's agricultural sector yet. Conceptually, these markets can enable producers to stack credits for producing various ecosystem services such as on-farm GHG reductions, improved water quality and/or enhanced biodiversity (Monahan et al., 2020). However, in Alberta research is being developed by organizations including Ecoservices Network and Alberta Innovates to better understand how these markets can be developed and scaled. Alternative to market approaches, the Alternative Land Use Services (ALUS) program is beginning to work directly with companies that are looking to meet their ESG objectives by supporting the expansion of sustainable agriculture. For example, Cargill and A&W are supporting 'Grazing Forward', an initiative of ALUS's New Acre Project, which is focused on scaling the adoption of regenerative practices to enhance carbon storage on ranches in the Prairies (ALUS, n.d.). While these projects are driven by industry support, a multistakeholder approach is taken in project development and delivery.

4.3. Civil society-led stewardship programs and advocacy

Parallel to the development of novel industry approaches to encourage NCS, existing governance mechanisms are increasingly examined for their potential to align conservation, biodiversity and climate action objectives (e.g., Monahan et al., 2018). This trend is observed through civil society actors' administration of payment for ecosystem service programs, environmental trust funds, and conservation easements. In particular, conservation easements are being explored as an approach to encourage NCS in agriculture landscapes that require the protection of grasslands, wetlands and forests (Hallstein and Iseman, 2021). In western Canada, conservation easements contribute to protecting grasslands, which is an important ecosystem for below ground carbon storage and home to many species at risk (Wang et al., 2014). For example, the Southern Alberta Land Trust Society (SALTS) projects that they will protect over 60 thousand acres of grassland by 2060 in Alberta (SALTS, n.d.). While this projection will have a positive impact on conservation, local ranchers and climate change, it is important to recognize that each individual governance mechanism may not be suitable for every producer and can create trade-offs of their own. Therefore, experts suggest that greater attention is needed to develop a diverse suite of governance mechanisms that appeal to a wide pool of producers with varying farm sizes, production types and tenure (IPCC, 2019).

On-the-ground, civil society actors are leading programs that enable NCS adoption. For example, The Nature Conservancy of Canada is working with ranchers in Alberta through a stewardship credit program to improve grazing practices and enhance riparian areas (NCC, n.d.). Civil society actors are also advocating for the development of governance mechanisms that make the adoption of NCS economically competitive and attractive for producers. Organizations including Farmers for Climate Solutions have mainstreamed advocacy in Canada for an enabling governance ecosystem

that can provide producers with the necessary tools, financial support and knowledge to effectively transition to low-carbon production without hindering their economic viability (Farmers for Climate Solutions, 2021). These advocacy efforts include pushing for the reform of policies that have perverse effects on conservation, on-farm innovation, and climate change mitigation (e.g., ECO, 2016). Lastly, civil society has emerged as a sector that excels at developing regional education and outreach programs. In particular, farmer-led organizations such as the Ontario Soil Network, host on-farm demonstrations, online networking opportunities and facilitate producer participation in research (OSN, n.d.). These initiatives enable producers to share their experiences and to learn about how other producers are adopting practices and technologies. Such efforts are grounded by research that shows producers, like many other sub-groups of society, prefer to learn from others that they can relate to (Sumane et al., 2018). Civil society organizations' current leadership roles in advocacy campaigns and in the expansion of education and outreach programs highlights their importance in fostering an enabling environment for producers to adopt NCS.

"Solutions are emerging on Canadian farms, but more remains to be done. To achieve economically successful farms and a healthy environment, farmers need support."

- Farmers for Climate Solutions



4.4. Multi-stakeholder projects and roundtables

It is increasingly less common for one actor to solely develop and implement a program or initiative that influences NCS in agriculture. This trend is accounted for within the inner rings of the Venn Diagram in Figure 1. Collaboration on NCS projects is described by practitioners as a key condition to promote meaningful engagement among a diverse pool of stakeholders (Hallstein and Iseman, 2021; USFRA, 2021). For example, a collaboration among diverse actors including the Canadian Forage and Grassland Association, Shell Canada, and Viresco are developing an offset pilot project under the Canada Grasslands protocol. In this pilot project, producers are estimated to receive approximately \$4 to \$25 per hectare for conserving grasslands that are at risk of conversion to croplands (CFGF, 2021). The importance of collaboration in scaling NCS is also emphasized as a critical component to leverage funding via programs such as Emission Reduction Alberta's Food, Farming and Forestry Challenge, which explicitly encourages partnerships within NCS projects that seek funding support. Governance mechanisms that

involve a diverse group of stakeholders are also demonstrating their capacity to improve coordination along supply chains and within commodity groups. In particular, roundtables can gather multi-stakeholder groups to pre-competitively determine best approaches to improve the sustainability of their products and supply chains. Roundtables can also play an important role in unifying communication and outreach strategies on sustainable agriculture. This is especially recognized through the work led by the Canadian Roundtable for Sustainable Beef (CRSB), with members including Birds Canada, JBS, and the Livestock and Forage Centre of Excellence at the University of Saskatchewan. With the support of its members, CRSB has made strides to set 2030 targets for GHG reductions in beef production, develop a sustainable beef certification program, and support on-farm conservation projects (CRSB, n.d.). These examples suggest that mixed forms of governance and multi-stakeholder collaboration have evolved as integral components of the governance ecosystem that influences NCS in Canada's agricultural sector.

5. Pathways Forward

In Canada, there are emerging governance mechanisms that have the potential to facilitate greater action and address some of the country's shortcomings that have stemmed from an uncoordinated approach. In particular, the national 2030 target to reduce GHG emissions from fertilizer application can enable the sector to advance initiatives that many producers are already familiar with such as the 4Rs of nutrient management. In addition, this target can be a driver for coordinating activities across the country to scale the adoption and measurement of improved nutrient management. Targets within the agricultural sector can play a key role in driving momentum. But, to ensure momentum translates into tangible outcomes, experts suggest national road maps or strategies are necessary to allow different actors to envision their role in meeting targets and to align their own objectives (OECD, 2019; Searchinger et al., 2020; Chabbi et al., 2017; Brady et al., 2019). Complementary to having targets and a plan to achieve them, it is necessary to also have robust measuring, reporting and verification systems in place to track progress. Like many countries, Canada continues to endure a slow development of such systems that can adequately account for NCS outcomes (Hönle et al., 2019). In addition, Canada has significant data gaps in NCS adoption rates and on-farm GHG budgets, which are necessary to adequately inform policy and program design (Hewins et al., 2018). In the 2021 Federal Budget, the Government of Canada proposes to enhance funding for Earth observation satellites (e.g., remote sensing) which can help address Canada's aging infrastructure needed for measuring, reporting and verification systems (Government of Canada, 2021). In addition, governance mechanisms that can propel the development and use of these systems such as carbon markets are rapidly evolving and show promise to scale private and public demand for reliable and accurate GHG measurements in agriculture.

Part of an enabling governance ecosystem for NCS in agriculture is having clear market signals that incentivizes their adoption. To finance NCS in agriculture, diverse stakeholders including international financial institutions, environmental non-governmental organizations and producer associations have emphasized the necessity to advance market mechanisms that position NCS as more economically viable compared to unsustainable practices and land use changes among current market conditions (Searchinger et al., 2020; Hallstein and Iseman, 2021; TSCVM, 2021; USFRA, 2021). There are a growing number of governance mechanisms being considered to steer investment towards NCS projects and foster favourable market conditions for producers adopting NCS. These governance mechanisms include green bonds, tax incentives and insurance for practice adoption (Olmsted and Sushant, 2021). Complementary to introducing new governance mechanisms to fund NCS, experts emphasize the need to reform existing agricultural policies, subsidies, and trade agreements that have perverse effects on climate change mitigation and innovation (e.g., Fellmann et al., 2018; Himics et al., 2018; Jansson et al., 2020). For example, these may include dated approaches in business risk management programs, poor land tenure conditions such as short-term leases, and tax incentives that reward the destruction of natural ecosystem (e.g., tax incentives for land improvements) (ECO, 2016). There are also opportunities to improve cross-sectoral collaboration on NCS strategies and reduce trade-offs between sectors (van Oosterzee et al., 2014; Di Gregorio et al., 2017). To create an enabling governance ecosystem for NCS, greater attention could be focused on building coherency within agricultural policy, fostering favourable market conditions and building synergies across all sectors.

For stakeholders, especially producers, to effectively navigate the rapidly evolving governance ecosystem that influences NCS, engagement at regional and local levels should be considered in the design processes of governance mechanisms (Hurlbert, 2014; Pérez Domínguez et al., 2020; Norton et al., 2020). For example, to improve access to education on NCS, experts including Seddon et al. (2019b) emphasize the need to foster partnership building among multiple stakeholders, including producers, to develop effective NCS initiatives. In addition, diversifying the

actors that are involved and invested in NCS projects can contribute to enhancing access to necessary funds and resources that can accelerate the process of scaling novel practices and technologies. This approach is observed in programs such as AAFC's Living Laboratories Initiative (which is built upon by the Agricultural Climate Solutions program), where partnership building is a cornerstone of successful projects. Further catalyzing innovative partnerships such as these can advance Canada's role as a leader in NCS research, innovation, and knowledge transfer.

5.1. Lessons from abroad

Moving forward, as Canada continues to develop and refine its approach to scaling NCS in agriculture there is an opportunity to look abroad and to learn from other countries' approaches and experiences. In particular, Canada could explore how other countries have developed GHG reduction road maps for their agricultural sectors. For example, Ireland's Department of Agriculture, Food and the Marine recently launched, Ag Climatise - A Roadmap towards Climate Neutrality, which outlines actions that can be implemented now and those that will need to be developed to reach the sector's GHG targets (DAFM, 2020). While there are tangible and impactful objectives outlined in Ireland's roadmap, observers have raised a few concerns. For example, a researcher from University College Cork, Ireland points out that the roadmap in its current state does not align with national 2030 climate commitments and requires considerable improvements to be aligned (Daly, 2020). This limitation of the road map is partly the reason why it is a living document. Responses to the launch of Ag Climatise such as Daly's (2020), suggest the importance of aligning policy frameworks to ensure national and sector targets are complementary.

Voluntary carbon markets are increasingly becoming an attractive mechanism to encourage NCS adoption. To grow NCS's place on voluntary markets, there is a need to provide stakeholders the assurance needed to view NCS as a reliable source of offsets (TSVCM, 2021; WEF, 2021). In Canada, key barriers to providing this assurance is the limited pool of active NCS offset projects and a lack of an existing policy framework (WEF, 2021). To enhance the robustness and legitimacy of voluntary markets, governments can play an important role by developing compliance markets, much like the forthcoming Federal GHG Offset System, which drive demand and provide assurance that NCS projects within the jurisdiction can produce credible offset credits (TSVCM, 2021). Governments can also enhance the legitimacy of carbon market actors, like the United States Senate aims to do through the bi-partisan bill, The Growing Climate Solutions Act. This bill authorizes the United States Department of Agriculture to establish a voluntary Greenhouse Gas Technical Assistance Provider and Third-Party Verifier Certification Program (United States Senate, 2021). These governance mechanisms are proposed to help address entry barriers that producers and forest landowners face when looking to participate in carbon markets (United States Senate, 2020). Ultimately, the Growing Climate Solutions Act proposes to improve access to reliable information about carbon markets and better connect producers to qualified technical assistance providers and credible protocol verifiers.



Carbon markets have recently captured the attention of producers across Canada as a means to be compensated for their climate action efforts, but it is worth noting that they are one option for financial incentives, among many, and may not adequately apply to and motivate every producer. Exploring governance mechanisms that incentivize producers to adopt NCS similar to carbon markets, but with different conditions and requirements for participation may be an important policy design exercise to scale NCS adoption. One example of such governance mechanisms is California's Healthy Soils Program where revenue from California's cap-and-trade system is put into a fund dedicated to offering

technical and financial support to producers that adopt NCS (CDFA, 2020). In this program, producers can use the COMET Planner tool to estimate their potential GHG reductions and payments based on proposed practice adoption (USDA, n.d.). Developing effective governance mechanisms is not as simply as a cut and paste from one jurisdiction to another. However, learning from these examples and how others have developed innovative approaches to enhance NCS in agriculture can better position Canada to create impactful, inclusive and resilient pathways forward.

6. Conclusion

The governance ecosystem that influences NCS in agriculture is diverse and growing, but uncoordinated. To improve the functionality of this governance ecosystem, we first need to understand what actors and governance mechanisms are already involved. This report responds to this need. In Canada, there are a variety of governance mechanisms led by the state, industry, civil society and combinations among the three. Governance mechanisms that directly influence NCS adoption include cost-share programs, value chain initiatives, and on-farm NCS research projects as well as those that indirectly influence NCS such as policies, incentivizes and subsidies with broader objectives such as sector innovation. The overview of the governance ecosystem presented here can help inform emerging governance

mechanisms to identify opportunities to leverage and coordinate with exist activities. In addition to enabling emerging governance mechanisms within Canada, this report highlights that there is also an opportunity to look aboard to observe and even adopt governance mechanisms that are active in other countries. While there are challenges and barriers within the current governance ecosystem, Canada is well positioned to build upon the momentum around NCS and foster a governance ecosystem that is capable of realizing the potential of NCS in agriculture. Lastly, as the research field of NCS in agriculture continues to expand, it is necessary that systems approaches are applied to enable a deeper understanding of the trade-offs and co-benefits that result from governance mechanisms.

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8. Appendix

Appendix A

Table 1. Complementary materials to Figure 1. This table outlines the types of regulations presented in Figure 1, their basic description, and examples of governance mechanisms for each type of regulation.

Types of Regulation	Description	Governance Mechanism	Example
State-led Regulation			
Hard Regulation	Governance mechanisms that invoke rules that are binding	Carbon taxes	Federal Fuel Charge
		Cap-and-trade systems	Alberta Offset System
		Environmental and conservation Acts	Greenhouse Gas Pollution Pricing Act
Soft Regulation	Governance mechanisms that suggest or facilitate desired behaviour	Climate action plans	A Healthy Environment and a Healthy Economy
		Agriculture policy and programming frameworks	Canadian Agricultural Partnership
		Sustainable agriculture action plans	Quebec's 2020 -2030 Sustainable Agriculture Plan
		Environmental funds and programs	Canada Nature Fund
		Climate action funds and programs	Agricultural Climate Solutions
		Research programs	Agricultural Greenhouse Gases Program
		National GHG Inventory	Canada's official greenhouse gas inventory
		Agri-environment indicator reporting	Agri-Environmental Indicator Report Series
Industry-led Regulation			
Industry Self-regulation	Governance mechanisms that steer industry practices with varying degrees of formalization and bindingness	Industry association initiative	Fertilizer Canada's 4R stewardship program
		Coalitions	We Mean Business Coalition
		Taskforces	Taskforces on Climate-related Financial Disclosures
		Certification schemes	Carbon Zero
Firm Self-regulation	Governance mechanisms that facilitate voluntary practices that enable triple-bottom line management	ESG/CSR reporting	Nutrien's ESG report Loblaw Companies Limited's CSR Report
		Conduct climate disclosures	Agropur Cooperative's CDP score
		GHG targets	Cargill's Science-based GHG target
		Obtain carbon neutral certifications	Maple Leaf Food's carbon neutrality certification
		Participation in PES markets	Alberta farms enrollment in the Conservation Cropping protocol
		Corporate value chain projects (Carbon Insetting)	Danone's approach to value chain interventions to meet carbon neutrality target

Civil society-led Regulation			
Civil Regulation	Governance mechanisms that ensure standards are met, facilitate informal pressuring, and contribute to the management of common pool resources	Advocacy campaign	Farmers for Climate Solutions' Budget Recommendations (2021)
		Education and outreach programs	Soil Conservation Council of Canada
		Farmer networking programs	Regeneration Canada
		On-farm research	Ontario Soil Network
		Incentive programs	The Nature Conservancy of Canada's stewardship credit programs
		Conservation easements	SALTS's conservation easements
		PES programs	ALUS Program
Co-regulation			
Public Co-management	Governance mechanisms that involve state and civil society collaboration	Conservation and environmental trusts	Manitoba Heritage Corporation administration of the GROW Trust
		Extension services	Nova Scotia Federation of Agriculture's delivery of the Environmental Farm Plan
		Cost-share programs	Ontario Soil and Crop Improvement Association's delivery of the LEADS program
		Manage public lands	Association of Manitoba Community Pastures
Public Co-regulation	Governance mechanisms that involve state and industry collaboration	Manage GHG reduction innovation funds	Alberta Emissions Reduction
		Promote research and innovation	Alberta Innovates
		Administer loans	Farm Credit Canada's Environmental Solution loans
Private Co-regulation	Governance mechanisms that involve civil society and industry collaboration	ESG-driven partnerships	ALUS' New Acre Project
		Education and technical support programs	General Mill's Regenerative Agriculture Oat Pilot
		Incentive programs	Ducks Unlimited Forage Program
		Agri-environmental reporting initiatives	Canadian Field Print Initiative
		Sustainable roundtables	Canadian Roundtable for Sustainable Crops
Tripartite Co-regulation	Governance mechanisms that involve state, industry and civil society collaboration	ESG frameworks	GRI and SASB
		Climate disclosure frameworks	CDP
		GHG accounting standards, tools and guidance	Greenhouse Gas Protocol Science-based Target initiative
		Manage PES projects	Canada Grassland protocol pilot project