Systemic Barriers and Drivers to Technology Adoption in Canada: Lessons for Agri-Innovation in Ontario from Stakeholders of Canada's Global Innovation Clusters

By M.A. Lemay, Allison Clark, Jeff Boggs, and Charles Conteh

INTRODUCTION

In this policy brief, we present the results of interviews conducted with stakeholders and partners of Canada's Global Innovation Clusters[1] (GIC, formerly Innovation Superclusters) on the development and adoption of automation and robotics technology. The interviews with the GICs constitute the third phase of a more extensive four-pronged study to investigate opportunities and challenges associated with building competitive production systems in Ontario's agri-food sector, focusing on the barriers and drivers associated particularly in the development and adoption of automation and robotics technology. We will provide a brief overview of the two earlier phases to put the present discussion in context.

In phase 1 of the project, the research team administered a province-wide survey of Ontario's agricultural community. The survey was meant to identify several key issues, namely:

1. the extent of adoption of automation and robotics technology by the Ontario agriculture sector;
2. the barriers/drivers to adoption;
3. where farmers have adopted innovative automation and robotics, were the original reasons for making the investments achieved, and were the outcomes positive, negative or neutral;
4. how barriers to adoption were overcome;
5. what steps could be taken to accelerate innovative automation and robotics technology transfer and adoption in the agriculture sector.

Additionally, the survey shed light on contextual factors shaping the adoption of new technologies, such as the farmers' interactions with agri-food laboratories and research centres, their perception of changing trends in these new technologies and how these might affect their businesses, the internal and external factors that influence their decisions to adopt automation and robotics technology, and difficulties encountered in achieving their business goals. The survey thus provided a quantitative portrait of the current barriers, constraints, drivers and opportunities of automation and robotics technology adoption in Ontario's agriculture sector.

The second phase of the project focused on Niagara's agri-food sector as a case study with 38 interviews conducted with farmers, technology developers, researchers and other agriculture stakeholders (e.g., commodity organizations, extension specialists and agri-businesses). The interviews enabled the research team to explore the factors shaping automation and robotics technology adoption in ways that cannot be directly observed in numbers. Moreover, focusing the lens on Niagara shed light on the factors that account for technology adoption within the context of a regional agricultural innovation system. For analytical consistency and cumulative insight, the interviews followed the same themes as the survey questions but with the added advantage of a more open-ended conversational format that enabled the research team to explore underlying issues and factors shaping automation and robotics technology adoption.

This is an Ontario Agri-food Research Initiative (OAFRI) project. OAFRI projects are funded through the Canadian Agricultural Partnership, a five-year, $3-billion commitment by Canada's federal, provincial, and territorial governments that supports Canada's agri-food and agri-products sectors.

[1] Government of Canada. 2022. "Budget 2022: A Plan to Grow Our Economy and Make Life More Affordable." P. 72. https://budget.gc.ca/2022/home-accueil-en.html. See also The Globe and Mail. "Supercluster program gets political renewal – and new name – from Innovation Minister Champagne." Published June 28, 2022. www.theglobeandmail.com/business/article-supercluster-program-gets-political-renewal-and-new-name-from

A summary of our findings from these earlier phases of the research suggests that widespread adoption of automation and robotics technologies by the agriculture sector is dependent on the following critical factors:

1. the need for technologies that provide solutions for farmers' real problems;
2. the need for new technologies to demonstrate proven/validated performance and benefits;
3. more than simply offering new technologies, there is a compelling need for equipment suppliers with reliable service, maintenance, and technical support over the life of the technologies;
4. governance frameworks for data that protect privacy and security as vital prerequisites for ensuring user confidence;
5. policies and programs that are configured to incentivize early adopters and support smaller farms to adopt innovations that improve their competitiveness.[2]

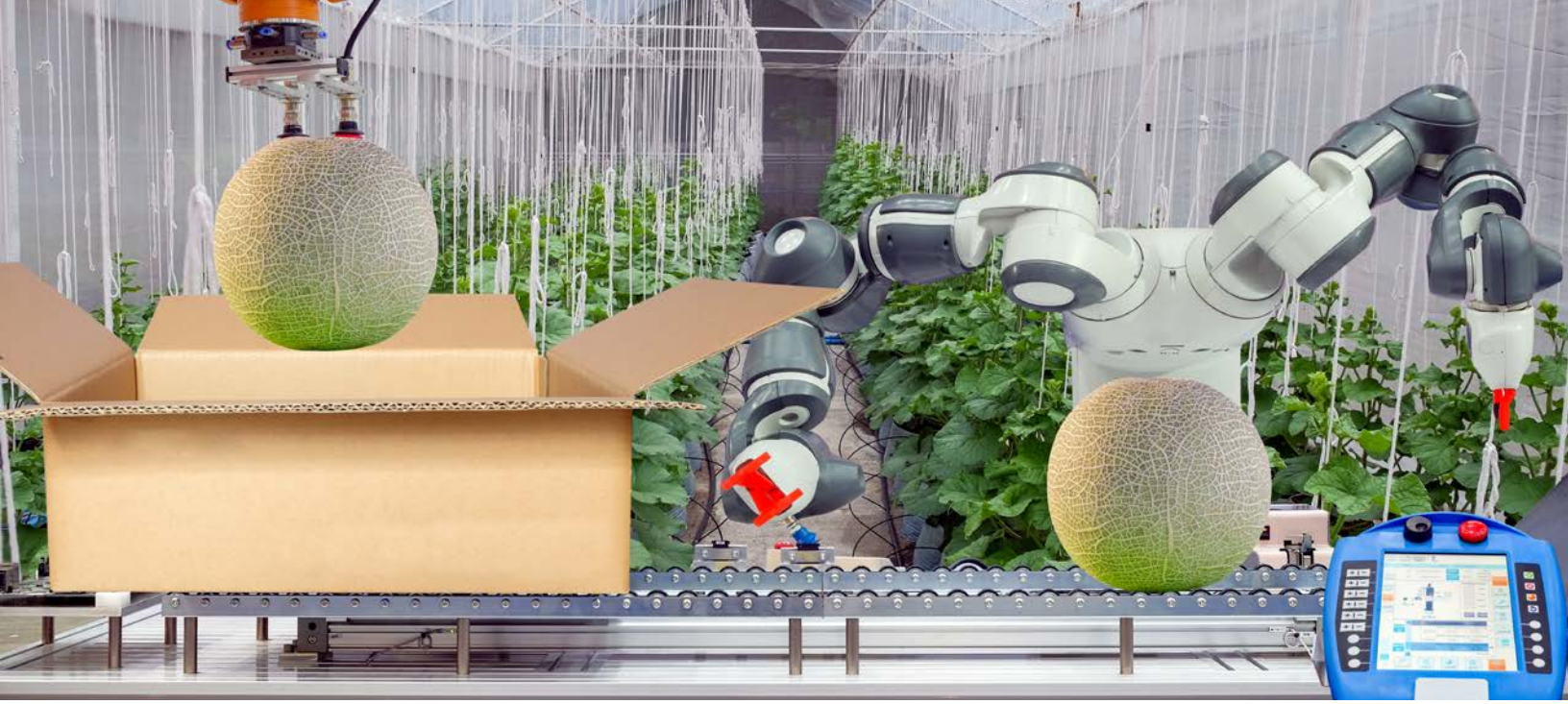
This policy brief builds on results from the two earlier phases but reports on the findings of a series of interviews conducted with partners and stakeholders of projects funded by the GICs. With this set of interviews, the focus shifts to research, technology development, commercialization and adoption at a national level. **The interviews provide insights into the challenges faced by researchers, technology developers and intermediaries in developing, scaling and commercializing automation and robotics technologies and their perceptions of barriers and drivers of adoption faced by their end-users, such as farmers.**

By expanding the analytical lens to the stakeholders and partners of the GICs, we highlight critical themes and patterns that can shape broader systemic barriers and opportunities facing technology adoption in the context of a national innovation system. The aim is to extrapolate from these wider systemic themes and issues to deepen our understanding of the opportunities, challenges and barriers facing the adoption of automation and robotics in Ontario's agriculture sector.

The policy brief is organized as follows: First, we describe the method and process of data collection and analysis for the GIC interviews. Second, we present the findings from an analysis of the interviews. Finally, we outline the next, and final, steps of the project, including a set of questions based on the findings reported here that will guide a series of multi-stakeholder focus groups. Insights generated by the focus groups will provide an additional empirical foundation informing our final policy recommendations and action steps that could accelerate the development and adoption of automation and robotics technologies in the Ontario agriculture sector.

---

[2] More detailed summaries of the previous findings have been published in a Working Paper (Lemay et al 2021a) and a Policy Brief (Lemay et al 2021b).



RESEARCH METHOD

Canada's GICs were created by the federal government under the Innovation Supercluster Initiative (ISI).[3] They were mandated to pull together technology clusters across the country into industry-led consortiums comprising networks of businesses, universities, research centres, public agencies and other stakeholders. Their purpose is to advance research and development, create intellectual property, and commercialize new ideas and technologies. Each GIC focuses on technology innovation in the economic sectors where Canada has a significant competitive advantage (namely, ocean sciences, artificial intelligence, advanced manufacturing, plant-base proteins and products, and digital technology).

One of the themes that emerged from the two earlier phases of the research project is the role of contextual factors that shape or influence the adoption of new technologies. A focus on the GICs and their partners as units of analysis thus provide a critical opportunity to investigate the cluster dynamics of technology development, transfer and adoption within national innovation systems. The interviews followed the same themes as the earlier two phases, for analytical consistency and cumulative insight. As with the Niagara case study, which represented a regional innovation system, the research team had the added advantage of an open-ended conversational format that enabled us to explore underlying factors shaping technology development and adoption in national innovation systems.

The interviews were conducted from October 2021 to March 2022 either by telephone or on MS Teams. Overall, 25 individuals from four of the GICs were interviewed: 11 from Protein Industries Canada, six from Next Generation Manufacturing Canada (NGen), seven from the Digital Technology Cluster, and one interview from Scale AI (Table 1). No interviews were conducted with partners from the Oceans Cluster. All interviews were recorded and transcribed. Each interview was classified by stakeholder type: researcher (1), technology developer (15), manufacturer (2), intermediary (7) (Table 1). Of the 25 interviews, 18 were with organizations that were directly involved in the agri-food industry.

Table 1: Number of interviews by Cluster and stakeholder category

	PIC	NGen	Digital Tech	Scale AI
Researcher	1			
Technology Developer	4	4	6	1
Intermediary	5	1	1	
Manufacturer	1	1		

[3] *https://ised-isde.canada.ca/site/global-innovation-clusters/en/about-canadas-innovation-clusters-initiative*

ANALYSIS AND DISCUSSION

In this section, we report our findings as core themes generated by analyzing the interviews.

LABOUR IS A COMPLEX DRIVER OF ADOPTION

Shifting trends in the labour force (exacerbated by the COVID-19 pandemic) have ignited an unprecedented and urgent need for automation and robotics. Labour was consistently mentioned throughout the interviews and seen as a vital driver in the adoption of automation and robotics technologies. There are multiple factors related to labour as a driver of adoption. The main labour factor driving adoption is that, with fewer people living in rural areas, the labour pool is reduced. Furthermore, fewer Canadians appear willing to do manual labour on farms. The result is that temporary foreign workers programs have been a central plank of Ontario and Canada's labour strategy for the agriculture sector since 1969 through the Seasonal Agricultural Workers Program (Bauder 2006). The COVID-19 pandemic fundamentally disrupted this strategy, resulting in an increased and massive agricultural labour shortage. According to an intermediary from NGen, this shortage opens up the potential of increased automation as a solution:

> *I know a lot of farmers weren't able to have those foreign workers come throughout COVID, which might provide more of a long-term incentive to show them that this workforce isn't always going to be there. So that could be a sort of a push.*

In addition to labour shortages, other labour challenges, such as increasing costs of labour and health and safety risks, are driving increased adoption. A technology developer from the Scale AI cluster explained:

> *And you know, given that Canada is not a very populated environment at all, and we all expect a certain amount of standard of living as in, we need to pay people to do work then … robotics is the only solution.*

However, adoption of automation and robotics presents new labour challenges. A different skill set is needed for developing and commercializing the equipment based on these new technologies, and technology developers are struggling to find these skills. According to an intermediary associated with the Digital Technologies cluster, there is a shortage of technology workers in Canada, and those available lack experience in agriculture:

> *On the ag-tech side, helping with people who are producing the technology…you need software developers. You need people on [the] hardware side of things. You need data scientists. But you also need all of those people to have intimate familiarity with the space that they're building tech for. I know that the number one challenge is finding people.*

This shortage, according to our interviews, occurs because people interested in technology often are not interested in agriculture. To rectify this shortage, some interviewees mentioned the need to reskill the labour force so that they possess specific agriculture skills and exposure along with technical skills. For example, an intermediary from the Digital Technologies cluster highlighted:

> *Food and agriculture tend to not be the number one field that tech students think of when they think of high tech. Like maybe they want to get more involved in fintech or they're super interested in health tech. So, there is a struggle of attracting tech workers to ag space.*

While there are concerns over job losses from automation, the consensus from the interviews is that there will be new job opportunities. Interviews revealed that many tasks associated with these new technologies required a fundamental shift in skills needed on a farm. A manufacturer from Protein Industries Canada explained:

> *People's jobs are going to be displaced because they're going to be automated away. And I think it'll happen … it may not happen as quickly as some people think and probably faster than a lot of people would like. But just being prepared for that. So, not at all looking at how many jobs are going to be lost due to automation, but how many new opportunities are going to be created because of automation.*

DATA: HOW TO MANAGE, USE AND PROTECT IT

The challenges of managing, using, harmonizing, sharing, storing and protecting the massive volumes of data that are generated by automation and robotics technologies are significant barriers to widespread adoption. This was also identified as a core theme in the Niagara interviews (conducted during an earlier phase of this research project, as described above).

Many interviewees were involved in projects collecting data at specific stages of the agri-food value chain to provide traceability and sustainability metrics. Others were working on projects that involved remote sensing, artificial intelligence and machine learning to better predict business and production processes on the farm or within a manufacturing setting. While many interviewees were excited to share the benefits of this data, there were pervasive challenges. For example, there is a lack of data interoperability, meaning that data collected on one system often cannot be easily combined with data collected on another. The challenge of interoperability is seen both on the farm with multiple systems unable to communicate and in the supply chain, where data cannot be shared among supply-chain partners. An intermediary from Protein Industries Canada offered this perspective:

> *There are issues with collection and interoperability between different solution providers and machines and between software, hardware, cloud solutions … the lack of interoperability between all these different systems and the fact that it doesn't appear like there's going to be one [common system]. There are so many good solutions that are somewhat pervasive already that it doesn't appear that there is going to be [a dominant player]. So then, because [the different system platforms] are not very interoperable with each other, the [farmer], I guess I'm speaking mostly about [farmers], but I think this [applies across] the value chain, they now have to do the integration of data many times. That's a pretty big hurdle that we're now asking them to go through to get to these promised data insights and greater levels of insight in terms of accuracy and productivity and things like that.*

Another challenge was that end-users (e.g., farmers, food processors and manufacturers) are often overwhelmed by the sheer quantity of data being provided to them. As these are new technologies, end-users usually do not have the time or skill set to manage and interpret the data. And even if end-users do have the time and ability, poor broadband connectivity in most rural communities means that farmers lack the digital infrastructure to fully support those tasks. An intermediary from Protein Industries Canada summed up some of the challenges related to data:

> *A lot of data is being collected and perhaps being stored on all these separated devices … the value is converging [the data] into one thing, but you need a lot of bandwidth in order to transfer that somewhere to do the analysis, which doesn't necessarily exist … data connectivity in Canada is a big challenge … so that is a barrier for some of this … because if you can't get the connectivity to transfer the data … in an easy way, we can't share it either.*

Beyond these challenges, numerous interviewees suggested that the immense value of the data generated by these technologies will not be realized and adoption will be limited until ethical and legal standards emerge around the security, privacy and ownership of the data.

TRUST IS CRUCIAL TO ADOPTION

Trust is a common theme among technology developers and researchers who struggle to convince investors to finance their technology, or end-users to adopt it. More than half of the interviewees made direct reference to 'trust' and the importance of building trust in the development and adoption of new technologies. A technology developer from the Digital Technologies Cluster talked about the role of trust in building meaningful relationships:

> *There's a lot of very, very smart people who are interested in all kinds of applications of farming and robotics, et cetera. But it's very hard to make meaningful connections into those groups, into the farming communities. In most of our cases where we see success, it's usually someone who comes from that sort of background, but then goes back with skills and trust and are able to sort of build those bridges.*

The difficulties in building trust have also been attributed to overstating the performance and benefits of the technologies, which makes building trust even more difficult. A technology developer from the digital technologies cluster used a colourful metaphor to describe the importance of building trust with the agriculture community in the adoption of automation and robotics technologies:

> *Part of it is that they've been sold technology rainbow and unicorn fairy stories …Yeah, part of it is trust. Farmers are all about trust. And if they don't know you, then good luck.*

If we unpack this quotation, it tells us that technology developers understand the importance and challenge of building trust with farmers. Yet, there is still the tendency to exaggerate the performance capabilities of their technology. Adding to the trust factor, many automation and robotics technologies are considered to be too immature and not sufficiently validated to demonstrate their merits.

A manufacturer from Protein Industries Canada offered his perspective on trust, as an end-user of new automation technology: needing to have confidence that the technologies they were adopting would perform as expected.

> *Being a relatively new process … we're finding there are lots of the kind of what I would call a standard set of instruments [that] aren't quite right for us. So, we've had to really be careful about evaluating the efficacy of certain garden variety sensors … The whole protein isolate business is pretty new. It's not a very mature business. So as a company, who is looking to move forward with that, you know, we certainly want to have a little more confidence in the products that we are buying. So, I think managing the risk on that side has been, you know, definitely up there with our concerns of bringing in new automation systems.*

In this case, it is about trust in the technology rather than the technology solution provider.

A NEED FOR FINANCIAL INCENTIVES TO DE-RISK DEVELOPMENT, COMMERCIALIZATION AND ADOPTION

Many interviewees saw the need for policies that mitigated the financial risks associated with the broader innovation process, from development through to commercialization and adoption. Most interviewees commented on the massive costs involved in the development and adoption of technology as a barrier to adoption. The costs and time associated with development and commercialization represent a major financial risk for technology developers. Among farmers, there are also multiple points in the development-commercialization-adoption pathway where they are expected to take on substantial financial risk. Testing or validating a new technology on the farm is a critical part of the commercialization process and requires several production seasons. Farmers are often expected to participate in these trials with little consideration of the risk involved. If the technology does not perform as expected, the farmer could lose some or all of the crop or livestock. Once a technology has been validated and is commercially available, adoption requires substantial capital investments as well as changes to production practices. Both represent a new set of risks faced by farmers. A researcher from Protein Industries Canada suggested:

> *It would be nice if the government or banks could back up adoption. [For example], the banks could compensate the financial loss for one year of yield change.*

Such a policy would acknowledge the risks faced by farmers. However, the need for financial incentives to de-risk across the innovation process was a recurring theme.

WEAK CONNECTIONS BETWEEN RESEARCHERS, TECHNOLOGY DEVELOPERS/SOLUTION PROVIDERS AND THE AGRICULTURE SECTOR

Technology developers and researchers tended to 'blame' farmers for not adopting their technologies. Technology developers and researchers appear to have a negative perception of farmers' business acumen. For example, some interviewees referred to farmers as having a 'libertarian streak', being 'stuck in old ways' and 'resistant to change', and overall labelled as slow adopters. Yet, based on our survey, the level of adoption of automation and robotics technologies by the Ontario agriculture sector (39 per cent) was on par with the levels of adoption by other economic sectors (e.g., manufacturers) (Lemay et al 2021a).

Several technology developers interviewed invoked the deficit model from science communications in describing farmers' reluctance to adopt. They believed that farmers were just not aware or knew about the technology and how important it was to their farms. 'If they only knew' was a common storyline used in the interviews. Perhaps the most emblematic example of this view is that of a technology developer from Protein Industries Canada:

> *Problem awareness is one of the big things. So, growers, let's say in western Canada … They've got five harvesters They've got radios and a cell phone. They say, ''Ya, I know how to harvest this field.' And not knowing that they don't have a very good plan or that they could create a better plan ahead of time and be more organized. And they don't even have the awareness. It's just what they've [been] doing. I think that problem awareness is the biggest piece.*

Our interviews indicate that technology developers and researchers do not seem to see farmers as entrepreneurs who manage inordinate risks beyond that experienced in other sectors. In general, technology developers and researchers tended to lack an understanding of the agriculture industry and the realities of farming. This was also noted in the Niagara interviews. Few of the technology developers had direct relationships or collaborations with their end-users. They attributed farmers' expectations for validated and proven technology as risk-averse. We believe this misconception about farmers and lack of engagement with them may be a critical barrier to adoption.

RESEARCH, TECHNOLOGY DEVELOPMENT AND ADOPTION TAKE TIME

This theme, centred around the concept of time, is well established in the extant innovation policy literature. However, this is particularly true for agri-innovation, which was clearly explained by an intermediary from Protein Industries Canada:

> *Innovation, agriculture and food technology is more challenging than straight-up technology and even more challenging than the pharma and biopharma space … [the] ag-tech industry has some significant structural differences, such as longer timelines, more cash as needed. Very early on, the regulatory and consumer acceptance issues need to be managed and addressed and thought through right at the very early stages of innovation.*

Another point related to time is that many interviewees noted that farmers are very busy and do not necessarily have the time to research which technology would best benefit their farm. An intermediary from Protein Industries Canada described the challenges faced by farmers in making decisions about which innovations to adopt:

> *In the ag-tech sector, there's so much technology out there and there are so many players and so many new emerging technologies. It's a matter of which one to focus on. And then my guess is that for the farmer, they've got a lot of disparate data and information and technology and applications that they have to manage in order to run their farm … There's nowhere that [information] converges [right now].*

This comment speaks to the need for increased coordination of and access to information about new agri-innovations to support decision-making about innovation adoption.

A suggestion that came up in the interviews was that business owners and farmers should adopt technology in a slow and incremental fashion because learning how to use technology takes time. Finally, the concept of technology customizability was frequently raised. Many farms and businesses require customized solutions, which take time and require patience to adapt and implement. Rarely does an off-the-shelf technology fit seamlessly into an operation; it requires modifications and involves learning curves.

CONCLUSION AND NEXT STEPS

This policy brief is a continuation of the research team's attempt to illuminate the challenges and opportunities associated with the adoption of automation and robotics technology. In doing so, the research team expanded the scope of analysis to examine the broader systemic opportunities and challenges associated with the adoption of technologies in the context of a national innovation system. The overarching aim was to extrapolate from these broader systemic issues encountered by stakeholders in Canada's global innovation clusters to inform our understanding of the adoption of technology in the agriculture sector. In this regard, the discussion above sets the stage for the fourth, and final, phase of the project, which will consist of a series of multi-stakeholder focus groups. Some of the issues we plan to address with the focus groups are as follow:

1. In what ways could public policy assist/support the agriculture sector in adopting technologies to accommodate labour shortages and shifts in the labour force?
2. What role could government and other stakeholders play in addressing challenges related to data (interoperability, security, access, and privacy)?
3. Given that the role of government in providing financial incentives for technology adoption is often complex and controversial, in what ways could government improve existing financial support schemes or create new ones to ease the risks associated with adopting automation and robotics technology?
4. How can the weak connections between researchers, technology developers/solution providers and the agriculture sector be strengthened?
5. Technology research, development, and adoption processes take time. How could government programs do a better job taking time into account when creating financial programs to accelerate innovation?

In addition to the fourth phase noted earlier, we are completing a global knowledge synthesis. This reviews and synthesizes existing literature from the last five years to identify the barriers and drivers of automation and robotics technology adoption in the agriculture sector. The research team will combine this global knowledge synthesis with findings from the four phases. This provides a solid empirical foundation for policy recommendations and action steps to inform evidence-based decision-making and program development that we hope will accelerate the development and adoption of automation and robotics technology in Ontario's agriculture sector. Our third and final policy brief will report the findings of this integrated data analysis and outline a set of specific policy recommendations.

REFERENCES

Bauder, H. (2006) *Labor Movement: How Migration Regulates Labor Markets*. Oxford University Press.

Lemay, M. A., Boggs, J., Conteh, C. (2021a). *Preliminary Findings of a Provincial Survey on the Adoption of Automation & Robotics Technologies in Ontario's Agriculture Sector.* Working Paper. Niagara Community Observatory, Brock University. BROCK-NCO-Working-Paper-WEB-FINAL.pdf (brocku.ca)

Lemay, M. A., Boggs, J., Conteh, C. (2021b). *Growing Agri-Innovation: Investigating the barriers and drivers to the adoption of automation and robotics in Ontario's agriculture sector*. NCO Policy Brief #53. Niagara Community Observatory, Brock University. https://bit.ly/3fgR9u0

About the authors

M.A. (Amy) Lemay, PhD, is a Research Fellow with the Niagara Community Observatory and Adjunct Professor in the Environmental Sustainability Research Centre at Brock University. Her research focuses on the social dimensions of agricultural innovation related to acceptance, adoption and knowledge mobilization.

Allison Clark, BSc, is a research assistant with the NCO and is completing her Master's in Sustainability through the Environmental Sustainability Research Centre at Brock University. Allison also works as a Research and Policy Analyst with the Information and Communications Technology Council. Her research focuses on the socio-ecological implications of climate change.

Jeff Boggs, PhD, is an associate professor in the Dept. of Geography and Tourism Studies at Brock University. Dr. Boggs is an economic geographer by training. He also services as the NCO Associate Director. His research and teaching interests include policy-relevant applied research, mixed methods, regional economic analysis, regional political economy, and Niagara's changing economy.

Charles Conteh, PhD, is a professor of public policy and management in the Dept. of Political Science at Brock University. He also serves as the NCO Director. His research and teaching interests are in the areas of Canadian and comparative public policy, public management, political economy, and governance with a special focus on innovation policy and economic development.

The Niagara Community Observatory (NCO) at Brock University is a public-policy think-tank working in partnership with the Niagara community to foster, produce, and disseminate research on current and emerging local issues. More information on the NCO office, and an electronic copy of this report, can be found on its website **www.brocku.ca/nco**

Contact

Charles Conteh, PhD
Director, NCO
Brock University
cconteh@brocku.ca

Brock University
Niagara Region
1812 Sir Isaac Brock Way
St. Catharines, ON
L2S 3A1 Canada

www.brocku.ca/nco
@BrockNCO