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The Role of Incubators and Accelerators in the Fourth Agricultural Revolution: A Case Study of Canada

Robert Newell [1,*], Lenore Newman [1] and Zsofia Mendly-Zambo [1,2]

[1] Food and Agriculture Institute, University of the Fraser Valley, Abbotsford, BC V2S 7M8, Canada; lenore.newman@ufv.ca (L.N.); zzambo@yorku.ca (Z.M.-Z.)
[2] School of Health Policy and Management, York University, Toronto, ON M3J 1P3, Canada
* Correspondence: robert.newell@ufv.ca

Abstract: The fourth agricultural revolution has resulted in technologies that could significantly support global efforts toward food security and environmental sustainability. A potential means for accelerating the development of these technologies is through business accelerator and incubator (BAI) programs. Using Canada as a case study, this study examines considerations around building agritech BAI capacity for supporting transitions to sustainable, resilient food systems. The research employs expert stakeholder interview and thematic coding methodology to identify opportunities, success factors, challenges/barriers, and actions/approaches for increasing agritech BAIs in a region/country. The study also identifies findings that are broadly applicable to BAIs in general and those that are specific to sectoral (i.e., agritech) and place-specific (i.e., Canada) contexts. The analysis identified four opportunities themes, seven success factors themes, eight challenges/barriers themes, and eight actions/approaches themes. Of the four thematic areas, success factors were the most broadly applicable to different sectoral and place contexts, and challenges/barriers were most specific to the agritech and (to a lesser degree) Canadian contexts. The study elucidates roles, challenges, and ways forward for building agritech BAI capacity in regions and countries for harnessing the opportunities presented by the fourth agricultural revolution and transitioning to sustainable and resilient food systems.

Keywords: agricultural technology; fourth agricultural revolution; business accelerators and incubators; sustainable food production

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1. Introduction

A series of technologies has emerged (and is emerging) through the so-called 'fourth agricultural revolution', which have the potential to reshape food production and distribution across the world. Such technologies include those that support new approaches to farming such as digital, precision, vertical, and cellular agriculture, and involve advancements in tools and techniques in multiple fields such as robotics, blockchain, gene editing, drones, and synthetic proteins [1–3]. These new approaches and technologies present promising opportunities for transitioning toward sustainable food systems by enabling sufficient food production to feed a growing global population while minimizing environmental impact, arguably one of most pressing challenges of the modern Anthropocene epoch [4]. For example, the use of robotics, artificial intelligence, and machine learning in controlled indoor agriculture can be implemented to optimize farm management and crop harvesting, while minimizing land and water use [5,6]. As another example, new cellular agriculture methods for manufacturing animal proteins using tissue culturing and fermentation techniques have garnered attention for their potential to produce foods that are equivalent or near-equivalent to their animal counterparts, but with a much lower environmental footprints [7,8]. Such technologies could form essential components of efforts toward optimizing food security and environmental sustainability objectives worldwide.

The fourth agricultural revolution presents promising solutions for sustainable food production; however, issues exist with simply resting hopes on the potential of its emerging technologies. It is questionable as to whether the pace of technological commercialization and adoption is sufficient to meet the contemporary challenges of producing food in the Anthropocene. As explained by Rockström et al. [9], one of the urgent challenges of the new epoch is to transform these systems in a manner that meets global food demand while avoiding further degradation of the environment and remaining within the planetary boundaries of Earth's 'safe operating space'. In related work, Willett et al.'s [4] global assessment of food production, nutrient, and planetary boundaries illustrates the impact of current approaches to agriculture, with food production being a major source of methane and nitrous oxide greenhouse gases and a primary driver of land systems change and habitat loss. Furthermore, recent reports from the Intergovernmental Panel on Climate Change and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem have respectively articulated the severity of the climate change [10] and biodiversity [11], with both reports confirming that agriculture significantly contributes to and is impacted by these issues. There is a clear need for timely and widespread implementation of new methods for producing high-yield, nutritious foods with minimal environmental impact. Accelerating the development, availability, and adoption of technologies and innovations that support sustainability food production could be valuable for making progress toward this objective.

A potential means for accelerating the development of agricultural technologies and advancing the fourth agricultural revolution is through business accelerator and incubator (BAI) programs. BAIs have been found to be beneficial for increasing the business viability of technology companies; for example, research has shown that companies who have participated in accelerator programs have higher valuations [12] and an increased ability to acquire investment and funds [13]. Incubators have been found to be similarly beneficial; incubated companies have higher growth rates and a greater ability to access public funds than those that have not benefited from these programs [14]. Because of their ability to help companies grow and thrive, BAIs that support technology enterprises in turn can contribute to the spread and adoption of technologies produced through these companies. In support of this notion, Roberts and Lall [15] argue that accelerators could be valuable for harnessing the benefits of innovations of 'impact-oriented entrepreneurs,' meaning entrepreneurs that apply their creativity and ingenuity to social and environmental issues. Similarly, Surana et al. [16] discuss how incubators can serve an important role in stimulating and scaling technologies and innovation with the potential to contribute to the UN Sustainable Development Goals [17]. It follows that BAIs centered on agricultural technology, or agritech BAIs, could play a role in addressing the critical challenge of how to feed a growing population while minimizing (and even reversing) environmental degradation.

There are BAIs that operate in the agriculture sector, and some countries have benefited from these programs with respect to enhancing their agritech development capacity and capabilities, such as Singapore and the Netherlands [18]. However, as sustainable food production is a global challenge, there is room to grow agritech BAI capacity worldwide. With this in mind, the current research aims to elucidate considerations around how to build agritech BAI capacity for supporting transitions to sustainable, resilient food production systems. The research examines Canada as a case study, and it employs expert stakeholder interview methodology to identify opportunities, success factors, challenges, and actions/approaches for increasing agritech BAIs in a region/country. In addition, the study illustrates considerations for BAIs operating specifically in the agritech space and the applicability of the findings by identifying findings that are broadly applicable to BAIs across the world and those that are specific to sectoral (i.e., agritech) and place-specific (i.e., Canada) contexts. The results of the work provide insights on how different jurisdictions can stimulate and spur growth in agricultural technology and innovation, as well as the role agritech BAIs could potentially play in transitions to better food production systems in the fourth agricultural revolution and Anthropocene.

2. Materials and Methods

2.1. Characterizing Business Incubators and Accelerators

No standard definition exists for BAIs [19]; however, some reports and scholars have provided useful descriptions for understanding what these programs are and how they operate. In a 2019 BAI world ranking report, UBI Global provides classifications of incubator, accelerators, and hybrid programs, describing incubators as programs that support early-stage start-ups, accelerators as programs that focus on growing later-stage start-ups, and hybrids as programs that possess characteristics of both incubators and accelerators [20]. Other descriptions of BAIs include Schwartz's [21] discussion on key characteristics of effective incubators, these being networking, subsidized rental space, credibility, business assistance, and collectively shared facilities. Descriptions of accelerators note that they differ from incubators in that they are geared towards providing seed money for investment and equity [22], and Del Sarto et al. [23] regard these programs as extensions of the business incubator model. However, common characteristics are shared by incubators and accelerators. Wise and Valliere [24] note that effective accelerator programs provide office space, networking, and legitimization, while also discussing other supports such as investment, branding, and mentorship. Relationships can be seen among the key features of BAIs, such as networks enabling opportunities for investment through connecting start-ups with venture capitalists [21] and affiliation with a credible BAI can lend to the credibility, branding, and legitimization of participant start-ups.

Although no single definition of BAIs exists, a common understanding of what these programs do is observed in the literature. Succinctly stated, BAIs support start-ups and facilitate their growth through the provision of workspace, networking opportunities, mentorship, business assistance, and access to funding, while also benefiting these companies through their association with a respectable incubator or accelerator program. Figure 1 illustrates the key features of BAIs, drawing upon the characteristics of effective programs provided by Schwartz [21] and Wise and Valliere [24].

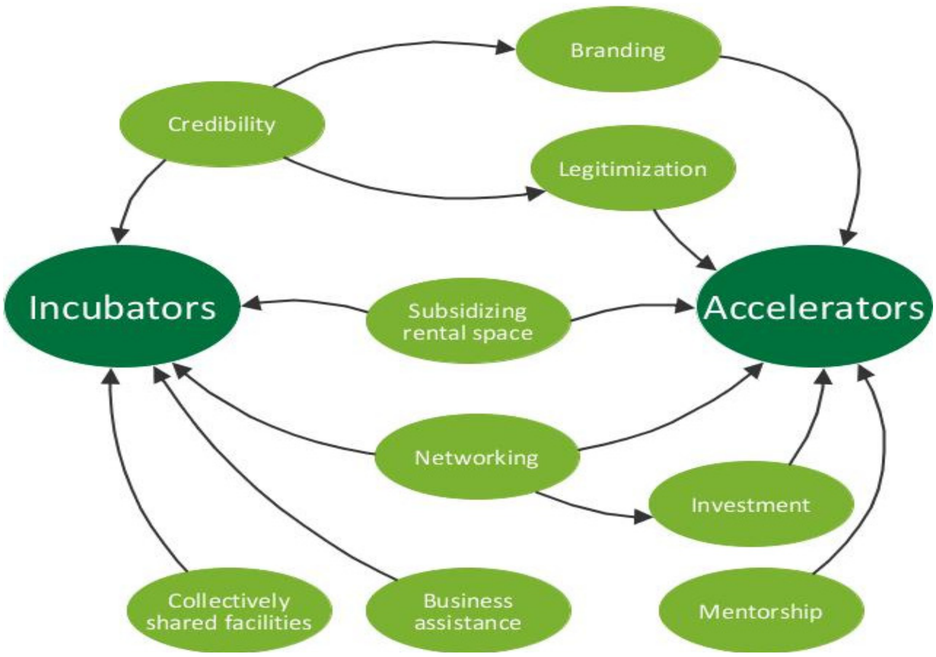

Figure 1. Key features of BAIs as per Schwartz [21] and Wise and Valliere [24].

The specific number of BAIs operating throughout the world is difficult to determine due to informal programs that are not labelled as BAIs but serve similar functions [25]; however, estimates indicate that is the magnitude of thousands. The first incubator was established in the late-1950s in New York [26], and over half a century, the total number of these programs grew to exceed 7000 globally [27]. Accelerators emerged later than incubators; the first accelerator, Y Combinator, was launched in 2005, and over the following decade these grew to over 3000 worldwide [28].

The growth of BAIs worldwide has been beneficial for technological advancement; however, many BAIs have sectoral focuses, and thus some sectors may have benefited more than others. Some surveys indicate that digital and information technologies may be stronger focuses for BAIs; for example, Bone et al. [29] found this sectoral focus comprises 29% of the incubators in the UK, the second highest category with the highest being 'no particular focus'. Similarly, through a global survey of over 300 accelerators, the Global Accelerator Learning Initiative (GALI) identified information and communication technology to be the largest sector-focused category of accelerator programs, consisting of 17% of the total sample [30]. In contrast, BAIs operating in the agricultural sector only comprised approximately 2% and 9% (respectively) of the sampled incubators and accelerators. Such findings indicate that there is potential room to grow agritech BAI capacity across the world; doing so could help advance agricultural technologies and innovation at a pace similar to that seen with information and digital technologies in recent decades.

2.2. Case Study

Canada is the case study for this research, and it serves as a useful focus for an investigation on agritech BAIs in part due to how active the agricultural industry is in the country. Canada has a strong agricultural sector, with over CAD 72 billion in farm gate receipts reported for 2020 [31]. The country also has a large land base, being the second largest country in the world; accordingly, it produces a wide range of agricultural goods. Agriculture and Agri-Food Canada [32] reports that in 2018, Canada farm receipts amounted to CAD 23.2 billion for grains and oilseeds, CAD 13.4 billion for red meat, CAD 6.6 billion for dairy, CAD 5.7 billion for fruits and vegetables, CAD 4.3 for poultry and eggs, and CAD 4.8 billion other crops. Such figures illustrate the variety of different agricultural products that are economically significant in Canada, ultimately speaking to the strength and diversity of the country's sector in terms of production and sales.

Canada also serves as a useful case study for this research because it has room to grow agritech BAI capacity. Canada lags behind countries such as Singapore and the Netherlands, which have effectively stimulated and accelerated technological development and innovation in the agricultural sector through BAI programs [18]. This is not to say that Canada agritech BAIs (or programs that operate in a similar manner to BAIs) are absent in Canada; this research collects data from such programs. Rather, this paper argues that there is room to grow agritech BAI capacity in the country and that efforts to do so would greatly enhance fourth agricultural revolution technologies in the country. Supporting this position is Williams's [33] report on the BAI Performance Measurement Framework pilot project conducted in Canada, noting that from a sample of over 500 Canadian companies which have participated in BAI programs, 76% reported these programs to be either 'vital' or 'significant' to their success. Canada therefore serves as a useful case study for this research because it currently has a strong and diverse agricultural sector but lags in agritech BAI capacity, even though these have demonstrated to be valuable for supporting and advancing entrepreneurial innovation in the country.

2.3. Data

This study is part of a larger project that specifically focused on accelerating technological development and innovation in Canada's agriculture sector, and the research involved literature reviews, an environmental scan of BAIs operating in agritech, and semi-structured interviews with expert stakeholders that operate within Canada's agricultural sector. The data collected through the later activity produced insights that were applicable beyond the Canadian context, and the current study conducts analysis on these interview data to capture these insights and develop this contribution to agritech BAI literature.

Semi-structured interviews were conducted with 10 participants, following other research that uses small, purposive samples of expert stakeholders with specialized knowledge (e.g., [34,35]). Participants included people working in incubator or accelerator programs (or BAI-like/BAI-related programs) that operate in the agricultural sector, BAI participants that work in the agritech space, and advisors and affiliates of these programs. Three interviewees were academics, and this group included people who sat on boards of an agritech accelerator program (n = 1), were involved in government commissions on BAI policy (n = 1) or sat on advisory boards for agritech start-ups and food production innovation granting programs (n = 1). Three interviewees were involved in BAI or BAI-like programs, and affiliations included an accelerator that focuses on agritech companies (n = 1), an accelerator that focuses on sustainable technologies and supports agritech start-ups (n = 1), and a program that supports and aims to build the capacity of small- to medium-enterprises in the agrifood sector through activities such as food innovation grants and network building (n = 1). One interviewee worked in a program that focuses on mobilizing knowledge in, developing networks around, and increasing uptake of agricultural innovations (n = 1). Two interviewees were founders of start-ups that operate in the agritech space and have participated in BAI programs (n = 2). One interviewee was an angel investor in and advisor for early-stage agricultural companies (n = 1). Demographic data were not collected for this group; however, it was inferred from participant biographies that the sample consisted of more male (n = 7) than female (n = 3) participants and more mid-/late-career (n = 7) than early-career (n = 3) participants.

Interviews were conducted in early-2021 by Zoom video conferencing software, and each interview lasted approximately 1 h. The interview protocol was designed to solicit information about the stakeholder's program/organization, the success factors for an incubator/accelerator (including key partnerships and networks), challenges and barriers, approaches for overcoming challenges/barriers, and potential benefits and societal impacts of agritech BAIs. Accordingly, interviews contained five sections: (1) details about the organization/initiative and the interviewee's role and involvement with BAIs, (2) successes, both in terms of where a program or initiative has been successful and what contributed to its successes, (3) challenges and barriers for achieving successes, (4) networks and partnerships associated with a program or initiative, and (5) societal impact of a program or initiative and future plans (or aims/hopes) for increasing this impact. Interviews were semi-structured, meaning interview questions were prepared for each of the five sections (3 to 6 per section), and other questions were asked to probe further into an insight or topic of interest (i.e., insights/topics which emerged through the interviews that were particularly pertinent to the research objectives). The interview protocol was tailored to different participants in a manner that allowed them to speak from their own experiences; for example, the wording of the questions differed depending on whether the participant worked in an incubator/accelerator or participated in one of these programs.

This study was approved by the University of the Fraser Valley's Human Research Ethics Board (file number: 100619). Participants were provided with letters of consents, which were signed and returned to the researchers via e-mail. Prior to starting interviews, researchers provided a brief summary of the project's objectives, and participants were given an opportunity to ask questions about the project and/or letter of consent.

2.4. Analysis

The analysis employed thematic coding methodology [36,37]. Audio data were transcribed to text (stored in Word document format), and the transcripts were subsequently imported into NVivo (release 1.5.1). An inductive coding method was employed in a process that involved both applying and revising the coding framework as data were further reviewed and analyzed [38]. This method first involved open coding, where themes were identified in the interview transcripts as these data were reviewed, and codes were applied to the text accordingly using NVivo's coding function. The interview data and codes were reviewed again to refine the coding framework by aggregating codes to create a more concise list/collection of themes. This aggregation occurred when there were few references in the data for a particular code (e.g., 1 or 2) and when a code could be included within a common theme with another code. Altogether, 42 codes were applied through this process.

After the inductive coding process, a deductive coding approach was used to specifically identify which aspects of the data referred to opportunities, success factors, challenges/barriers, and actions/approaches for addressing the challenges and for increasing agritech BAI programs and capacity. This process involved creating a coding framework prior to coding (i.e., rather than open coding and identifying themes as data were reviewed), and this framework consisted of the four aforementioned areas of interest (i.e., opportunities, success factors, challenges/barriers, and actions/approaches). Using NVivo, these codes were applied to the text in the appropriate places, and subsequently, a coding matrix was created to reveal overlap between the inductively- and deductively-applied codes. Such overlap was examined to group data coded through the inductive coding work within the four deductive coding categories. After this grouping was done, an axial coding process was performed [39], which involved further grouping coded data within the deductive coding categories to identify coherent, emergent themes related to opportunities, success factors, challenges/barriers, and actions/approaches.

Although this research project uses Canada as a case study, it produced findings that are broadly applicable to other regions and countries. Similarly, the research focuses on BAIs operating in the agricultural sector, but some of the findings are applicable to BAIs in general. To highlight the relevance of the findings to narrower and broader contexts, the emergent themes were examined to determine whether they relate to (1) agritech BAIs or BAIs in general, and (2) BAIs in Canada or BAIs in general. The results of this work are presented with thematic analysis to provide a greater understanding of the utility and applicability of the insights produced through this research. It is important to recognize that although some findings relate to a Canadian context, other regions/jurisdictions may have similar geographical, social, political, cultural, and/or economic features; thus, some seemingly Canadian-specific findings could have broader applicability.

3. Results

In total, 27 coherent themes emerged through the analysis. The distribution of themes among the deductive coding categories consisted of four relating to opportunities, seven relating to success factors, eight relating to challenges/barriers, and eight relating to actions/approaches. With respect to relevance and applicability, the analysis found that challenges and barriers were proportionally highest in terms of their specific relevance to building BAI capacity in the agritech sector and in Canada; whereas, findings around success factors were the most broadly applicable to different sectoral and place-based contexts. Table 1 provides a summary of these results.

Table 1. Summary of emergent theme numbers and specificity to BAIs in agritech and Canada.

Category	Emergent Themes (n)	Relevant Codes (n)	Themes Specific to BAIs in:	
			Agritech (%)	Canada (%)
Opportunities	4	13	50	25
Success factors	7	18	14	0
Challenges and barriers	8	19	75	50
Actions and approaches	8	21	50	13

3.1. Opportunities

Four themes emerged from the analysis of opportunities. Each theme was generally applicable beyond the Canadian context, but half were particularly relevant to building BAI capacity specifically in the agricultural sector. Table 2 displays a summary of the opportunities analysis results, and descriptions of the themes are provided below.

Table 2. Opportunities related to increasing agritech incubator and accelerator capacity.

Emergent Themes	Codes	Specific to BAIs in:	
		Agritech	Canada
Guiding direction of food systems technology and innovation	Climate change, Resource consumption, Food security, Economic viability, Biodiversity, Waste	Yes	No
Developing/enhancing value chains	Gaps, Network formation, Value chain	Yes	No
Harnessing student creativity and entrepreneurial spirit	Creativity, Culture	No	No
Increasing virtual engagement to connect people across expansive geographies	Online tools, Geography	No	Yes

An opportunities theme that clearly illustrated the potential role of BAIs in transitioning to sustainable food production relates to how BAIs can guide the direction of food systems technology and innovation through aligning their programs' admission criteria with sustainability goals. Interviewees gave examples such as creating programs for clean technologies and innovations, which can reduce agriculture-related greenhouse gases. Other examples included innovations that contribute to the production of predictable and high crop yields, while reducing land and resource uses. In addition, the data analysis elucidated opportunities for agritech BAIs to help enhance and strengthen food value chains, as these programs can help identify value chain gaps or challenges where technology and innovation would best be directed. In addition, BAIs can develop their networks to create business-to-business relationships that address such gaps. These findings illustrate how agritech BAIs can play a strategic role in developing resilient food production systems.

Other opportunities include the potential for capitalizing on the increased interest in entrepreneurship among students (i.e., skilled workers with specialized knowledge). An interviewee noted that modern student culture is conducive toward the proliferation of start-ups, as (from their observations and long experience working in academia) an increasing number of graduate students are attracted to this career path. Although not specific to the agriculture sector, opportunities exist to harness students' creativity and entrepreneurial spirit for agritech by establishing more university-based (or university-affiliated) agritech BAI programs. Other opportunities that are broadly applicable to BAIs observed through this analysis include virtual engagement opportunities. Interviewees noted that people have become increasingly comfortable with online engagement and tools, particularly during the COVID-19 pandemic. Although it was clearly expressed that agritech BAIs need physical space and infrastructure (e.g., labs, greenhouses), it was also articulated that these programs could benefit from virtual engagement complements to increase network development, especially in geographically vast areas such as Canada.

3.2. Success Factors

Seven themes were identified through the analysis on factors for improving the success of agritech BAIs. Most of the success factors themes were broadly applicable to BAIs in general, with only one that was specific to the programs operating in the agricultural sector. In addition, all themes were applicable to place contexts beyond Canada. Table 3 displays a summary of the results of the success factors analysis, and more detail on the themes is provided below.

Table 3. Success factors related to increasing agritech incubator and accelerator capacity.

Emergent Themes	Codes	Specific to BAIs in:	
		Agritech	Canada
Forming supportive networks	Investors, Knowledge sharing, Network formation, Value chain	No	No
Providing mentorship and support	Administrative support, Business guidance	No	No
Providing valuable affiliations and increasing visibility	Credibility, Publicity	No	No
Establishing a diverse advisory committee	Academic, Diverse perspectives, Technical expertise	No	No
Aligning programming and guidance with public policy	Climate change, Public policy	No	No
Developing effective success indicators	Economic viability, Metrics	No	No
Obtaining significant seed funding	Funding, Research infrastructure, Scale	Yes	No

Interviewees identified several success factors that were relevant to BAIs in general. Such factors include a BAIs ability to form and connect start-ups to supportive networks of diverse actors, such as investors, industry advisors, and different companies operating within the value chain (e.g., potential business-to-business opportunities). Other factors include mentorship and support/guidance in areas such as administration, business, and legal considerations were noted to be key features of BAIs, particularly those that harness and foster the talent of people working/studying in STEM disciplines with little knowledge and experience in other aspects of running a company. A theme related to affiliation and visibility was also identified, referring to the value of a start-up associating with a credible BAI, or a BAI affiliated with a credible institution (e.g., a respected university) for increasing their profile and the visibility of their company, services, and/or products.

Other themes that emerged through the success factors analysis include selecting an advisory committee that captures the diverse expertise needed to support agritech start-ups, that is, technical, scientific, and business expertise. It was also noted that BAI programs (and their participants) would be more successful when tailoring toward technologies and innovations that align with policies and market needs, an example being technologies that help industry players meet greenhouse gas emissions reductions mandated or incentivized by government agencies. Another success factor involved determining effective ways of measuring BAI 'success'; for example, the number of successful businesses (e.g., survival over a multi-year period) and value returned to the agricultural sector was noted to be a better success metric for agritech BAIs than simply the number of companies that completed the programs.

A success factor theme with specific relevance to the agriculture sector was the need for obtaining significant seed funding. It can be argued such funding is needed for any BAI; however, agritech research and development in particular is confronted with the challenge of needing large amounts of space (e.g., test farms) and expensive infrastructure (e.g., greenhouses, labs). Such resource needs are particularly pronounced in the agricultural sector, arguably more so than in the development of (for example) software and online applications. Accordingly, sufficient and significant seed funding was identified as a success factor particular to BAIs centered on agricultural technology and innovation.

3.3. Challenges and Barriers

Eight themes were identified through the challenges and barriers analysis. Three quarters of these themes (75%) capture challenges and barriers that face BAIs specifically in the agricultural sector, and half of the themes are particularly relevant to the Canadian context. Table 4 provides a summary of the results, and further discussion on themes is given below.

Table 4. Challenges and barriers related to increasing agritech incubator and accelerator capacity.

Emergent Themes	Codes	Specific to BAIs in:	
		Agritech	Canada
Venture capital culture	Investors, Risk, ROI	Yes	Yes
Perspectives on agriculture	Culture, Rural perception	Yes	Yes
Attracting/retaining companies and talent	Attraction/retention, Technical expertise, Regulations	Yes	Yes
Silos and geographical separation	Geography, Governance	Yes	Yes
Price and scaling-up	Affordability, Marketability, Scale	Yes	No
Diversity of agricultural technologies and approaches	Funding, Specialization, Technical expertise	Yes	No
Single university affiliation	Academic, Diverse perspectives	No	No
University-style programming	Flexibility, Research infrastructure	No	No

Half of the challenges and barriers themes are particularly relevant to both the agritech and Canadian contexts. One such theme relates to the venture capital culture in Canada, noted by an interviewee to be more risk-averse than in other countries such as the United States. This is particularly problematic for attracting funds to agritech start-ups, as the development of agricultural technology is expensive with long returns on investment and sometimes unclear profitability (such as with farm data collection platforms). Another Canadian agritech BAI challenge concerns the perspective on agriculture commonly held by government, investors, and citizens in the country. An interviewee noted that agriculture is perceived through a welfare lens (i.e., a social good supported by farm subsidies), rather than as a wealth creator. Similarly, it was expressed that a commonly held view of agriculture is that it is a rural activity, rather than part of a dynamic technology environment.

Interviewees noted a significant Canadian challenge for some types of agritech to be the country's difficult and unclear regulatory pathways for getting food products to market; this could discourage companies and talent from establishing themselves in the country. The challenge can be regarded as particularly problematic in light of the fact that some emerging agricultural methods, such as cellular agriculture, require highly-specialized expertise that is sourced from small talent pools. Interviewees also discuss the issue around silos both in terms of departments and jurisdictions. For the former, it can be challenging to determine which governmental agencies have the mandate to support building agritech BAI capacity, as it relates to a variety of different areas such as agriculture, economic development, and science and technology, all of which have different governmental departments. In terms of jurisdiction, Canada is a geographical vast country with agricultural systems that differ by province, presenting challenges for BAIs with respect to forming cohesive agricultural innovation networks and coordinated agritech development pathways nationwide.

Challenges and barriers that were broadly applicable to agritech BAIs (i.e., outside the Canadian context) include the need for creating products that are priced competitively to meet consumer expectations for affordable food. Such affordability considerations present related challenges around how to scale-up production in a manner that benefits from economies of scale and results in commercially viable goods. Another agritech-related challenge relates to the diverse nature of technologies emerging through the fourth agricultural revolution. 'Agritech' is highly varied, consisting of technologies for supporting cellular agriculture, vertical farming, digital agriculture, etc. Each of these areas of technology require their own set of specialized, expensive equipment, thereby creating challenges for establishing agritech BAIs with the appropriate resources and infrastructure for supporting a range of emerging agricultural approaches.

Challenges for BAIs that are not specific to agriculture or Canada relate to the university affiliation of some of these programs. Although such affiliations are valuable for the credibility of BAI programs and their participants, they can also tie BAI programming to a single university's expertise and agenda, reducing the diversity of academic partnerships and potentially limiting types of program participants (i.e., college versus university students). In addition, interviewees indicated that some BAIs affiliated with universities can have the tendency of adopting university-style programming, with inflexible schedules that do not align with the irregular and busy schedules typical of start-up entrepreneurs.

3.4. Actions and Approaches

Eight themes were identified through the actions and approaches analysis. Half of the themes are particularly relevant to agritech, and a quarter of the themes relate to the Canadian context. Table 5 displays a summary of the results, and descriptions of the themes are detailed below.

Table 5. Actions and approaches related to increasing agritech incubator and accelerator capacity.

Emergent Themes	Codes	Specific to BAIs in:	
		Agritech	Canada
De-risking investment	Investors, Risk, Public policy, Marketability	Yes	No
Regulatory guidance	Commercialization, Economic viability, Regulations	Yes	No
Program specialization	Specialization, Research infrastructure	Yes	No
Value chain gap analyses	Gaps, Value chain	Yes	No
National agritech hubs	Geography, Hubs, Investors, Knowledge sharing, Network formation	No	Yes
International network formation	International markets, Knowledge sharing	No	No
Public funding and in-kind support	Funding, Food security	No	No
Diverse network formation	Diverse perspectives, Technical expertise	No	No

Half of the actions and approaches themes refer to ways of stimulating growth specifically in the agritech sector. One theme involves developing policies that create markets for agritech products (such as the clean technology examples discussed above), as well as providing tax breaks and incentives for agritech start-ups. Such actions would encourage entrepreneurship in agritech and potentially increase participation in agritech BAIs, as well as attract funding from investors. Agritech BAIs would also benefit from partnerships with regulators that can provide participant start-ups with expert guidance on pathways from bench experiments to products entering the market. Furthermore, as agritech is a highly diverse field, BAIs could consider specialization and focusing on building infrastructure for particular areas of fourth agricultural revolution technologies, such as cellular agriculture or vertical farming. Interviewees also expressed the importance of understanding the complete food value chains when developing agritech BAIs to identify gaps, strategically direct programming, and build networks and mutually beneficial business-to-business relationships within these value chains.

An actions/approaches theme that relates to national research hubs was identified. This theme is particularly relevant to the Canadian context, but also broadly relevant to BAIs and technological development and innovation in fields outside of the agriculture sector. A national hub was discussed as important for supporting agricultural research and forming research networks across a geographically vast and agriculturally diverse country. An interviewee also noted that a hub would help attract and direct investment, as it would provide a clear point of contact for agritech investors.

Three of the actions/approaches themes were found to be applicable beyond the agricultural and Canadian contexts. Interviewees noted that BAIs can have a tendency toward maintaining a domestic focus (as they often aim to encourage the growth of domestic businesses); however, extending BAI networks internationally is valuable to give start-ups access to diverse knowledge, larger investor pools, and potential export market opportunities. Interviewees also expressed the importance of increasing public funding for agritech and agritech BAIs to diversify from private investment sources. One interviewee noted that public funding in this space could be regarded as akin to infrastructure investment, in this case, food infrastructure that supports national food security objectives. The analysis also highlighted the importance of diverse networks and a variety of mentors for BAI programs. The analysis indicated that BAIs should partner with multiple post-secondary institutions to encourage participation from and harness the talents of students from a variety of college and university programs.

4. Discussion

This research explores considerations around building agritech BAI capacity for supporting transitions to sustainable and resilient food production systems, and to this end, it specifically studied the opportunities, success factors, challenges/barriers, and actions/approaches for establishing and growing agritech BAIs. Among these analytical categories, the opportunities findings mostly explicitly illustrated the potential role BAIs can play in transitions to sustainable food production. BAIs have the ability to define the criteria for admitting start-ups, and in the case of agritech BAIs, such criteria could include technologies and innovations that support food security objectives, while also contributing to goals in climate change, land and habitat conservation, pollution reduction, water conservation, etc. In addition, as found through examples provided by interviewees, agritech BAIs could focus on supporting start-up technologies that enhance economic viability of farming by increasing crop yield and predictability. In this way, BAIs can set agendas for supporting and scaling innovations that operate in the intersection between the three sustainability pillars, that is, the environmental, social, and economic imperatives of sustainable development [40]. This is significant as start-ups that participate in BAIs experience higher success and fewer economic challenges than those that do not [12–14]. Together, the ability for BAIs to define participant criteria and the advantage they provide to start-ups suggest that they could play a potentially important role in shaping a country's agritech landscape.

When considering the potential role of agritech BAIs in transitions to sustainable food production, it is important to recognize the dangers of technological optimism and that technological advancements alone do not comprise sustainability solutions [41]. Technologies that initially show promise for contributing to sustainability objectives could ultimately result in minimal benefits, or even greater adverse effects, if implemented without effective supporting policies and programs. For example, Newell et al. [42] found the use of hydroponic systems in livestock feed supply chains can result in greenhouse gas reductions, but only when the hydroponic systems are powered by low-carbon energy sources. Similarly, Lynch and Pierrehumbert [43] estimate that cellular beef could result in greater contributions to anthropogenic climate change than livestock beef over a long-term period due to greenhouse gas emissions associated with the energy and transportation involved in cellular meat production. Furthermore, Newman et al. [44] raised questions about the land and habitat conservation potential of cellular agriculture when crops used as production inputs (such as sugar for fermentation-derived dairy) are obtained through agricultural expansion. These examples highlight the importance of complementing the scaling and widespread adoption of technologies with supporting policies that ensure maximization of benefits, such as policies related to energy (e.g., [42,43]) and feedstock sourcing (e.g., [44]). Relatedly, this research found policy alignment to be a success factor for agritech BAIs and policy incentives to be a potentially effective approach for stimulating agritech. The findings in this study relate more to the economic viability and success of agritech start-ups; however, they also demonstrate the interplay between BAI programs and government agencies, as well as the potential roles BAIs can play as an intermediate between sustainable food policy objectives and the growth of agritech industries.

The findings of this study indicate that BAIs experience challenges that are particular to the agricultural sector. For example, the diversity of different forms of food production technologies and methods emerging through the fourth agricultural revolution (e.g., vertical farming, cellular agriculture) presents requirements for specialized, expensive infrastructure. This challenge is arguably more pronounced for agritech BAIs than (for instance) information technology BAIs.

Another challenge involves government, investor, and public perspectives on what agriculture should 'look like' and how it should develop. Interviewees noted that agriculture is often viewed as being part of a rural domain rather than as part of a field of dynamic technology. These findings relate to the concept of the 'rural idyll,' that is, a commonly held image of agriculture farming being an activity done in rural countryside and consisting of old technologies such as scythes, antique tractors, and wooden barrels [45]. The rural idyll fosters conceptions and imagery of food production places as a part of a romanticized past [46], positioning the role of farmers as actors in idyllic rural landscapes [47], rather than innovators and adopters of cutting-edge technologies. This study identified the challenge as especially relevant to the Canadian context, but it ultimately links to a broader discourse in agriculture. The finding speaks to the dichotomization of the conventional (i.e., large-scale, industrial) and alternative (i.e., small-scale, organic) agricultural paradigms, the former being defined by high-yield, technology-driven production and the latter consisting of labor intensive, environmentally friendly approaches [48]. Alternative agriculture emerged as popular paradigm in response to the negative social and environmental effects of technology-driven conventional agriculture [49], and in many ways, it relates or even contributes to the agritech challenge of shifting perspectives toward understanding of the role and value of emerging, novel technologies in sustainable food production systems.

Unlike the challenges and barriers, most of the success factors were broadly applicable to BAIs of all kinds. In fact, the findings of the study indicate that a number of the factors that contribute to successful BAIs are also essential features of effective incubators and accelerators, as described by Schwartz [21] and Wise and Valliere [24]. For example, this study found a key success factor for agritech BAIs to be an ability to form and connect start-ups to supportive networks of diverse actors, such as investors, industry advisors, and different companies operating within the value chain (e.g., potential business-to-business opportunities). As another example, mentorship and support/guidance in areas such as administration, business, and legal considerations were noted to be key features of BAIs for harnessing the talent of those who have technological expertise but no knowledge and experience in the business aspects of running a company. As a final example, the findings on the value of BAI affiliation relate strongly to the credibility component of effective incubators presented by Schwartz [21] and legitimization features/benefits of accelerators discussed by Wise and Valliere [24]. Such findings suggest that many of the critical components for the success of agritech BAIs are universal among BAIs operating in all sectors.

Similar to the success factors, the actions and approaches analysis produced findings that relate to sustainability practices done in a variety of sectors and fields. In particular, the importance of forming networks of diverse actors to address complex sustainability issues have been discussed as critical components of efforts toward other challenges such as climate change (e.g., [50]) and biodiversity conservation (e.g., [51]). In addition, this research identified importance of knowledge sharing programs and mechanisms, such as the development of a national agritech hub (or hubs), and in a similar vein, effective tools, platforms, and methods for knowledge sharing have been regarded as valuable for supporting a range of sustainable development efforts (e.g., [52,53]). In this manner, the 'ways forward' for effectively building agritech and agritech BAI capacity mirror (or perhaps draw upon) common aspects and practices for addressing sustainability challenges and advancing sustainable development goals.

5. Conclusions

Current dominant agricultural paradigms, namely conventional and alternative agriculture, are not sufficient for sustainably feeding the growing global population, as the former carries a large environment footprint while the latter is labor intensive and does not produce sufficient yields to feed the majority of the population [48,49]. It is clear that new paradigms and agricultural approaches are needed to transition toward sustainable food production systems in the Anthropocene. The technologies and innovations of the fourth agricultural revolution could potentially help in this pursuit, which presents a potential role for agritech BAIs. However, technological advancement alone does not equate to progress toward sustainability; thus, it is important to recognize and promote the specific roles BAIs can play in shaping the agricultural technology landscape and guiding alignment between policy and start-up innovation. Recognition is also needed of the unique challenges agritech BAIs face in order to overcome these issues so that growth of BAIs working toward agriculture solutions can occur at a pace seen in other sectors, such as information technology and health. Ultimately, by recognizing the roles, challenges, and ways forward for agritech BAI growth, regions and countries can harness the opportunities presented by the fourth agricultural revolution to transition toward better, sustainable, and resilient systems for feeding the world.

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