

A large, stylized yellow leaf graphic is positioned on the left side of the page. It consists of a central vertical stem with several large, pointed leaves branching out to the right. The leaves are a bright yellow color, and the stem is a slightly darker shade of yellow. The graphic is set against a light gray background that transitions into a white background on the right side of the page.

REPORT

April 2, 2024

A JURISDICTIONAL SCAN OF DIGITALIZATION IN AGRICULTURE

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1. INTRODUCTION

Today, agriculture accounts for 4% of global GDP, totalling nearly \$4.5 trillion, and employs more than a quarter of the global workforce (Nathan, 2023). By 2050, the average farm is expected to generate four million data points every day (World Bank, 2021) and the earth’s population is expected to be nearly 10 billion people – with nourishing the global population today already an issue, the need to make progress in agricultural productivity is becoming urgent (Ma, 2021). Fortunately, the Fourth Industrial Revolution (4IR) for agriculture (or Agriculture 4.0) is already global and accelerating quickly. For example, in 2017, a robotic farm in the UK harvested its first fully machine-operated crop – five tons of barley were sown, fertilized and harvested by autonomous vehicles (Voegelé, 2018). Everyday it’s becoming more apparent just how much room there is for the traditional farming industry to grow from digital transformation. The World Resources Institute indicates that we need to fill a massive food gap without using more land and at the same time, reducing greenhouse gas emissions (Ranganathan, Waite, Searchinger & Hanson, 2018).

To make matters worse, it’s estimated that roughly 40% of global food production goes to waste (Lim, 2022). Voegelé (2018) provides some examples of some promising tech business looking to reduce that 40% number. The digitization of agriculture is poised to help solve multiple problems in the production and mobilization of food around the world, while at the same time reducing the impact of the issues it causes.

So how do we fill the food gap without using more land? Can the digitization of agriculture enable humans to consume more food than we do today using less land? In other words, can we reverse the curve? The ‘curve’ is depicted in Figure 1, which demonstrates what reversing the curve would look like, essentially getting to a point where food production and consumption continues to rise while the amount of land used to create that food actually goes down.

Illustrative: Potential effect of the digitization of agriculture

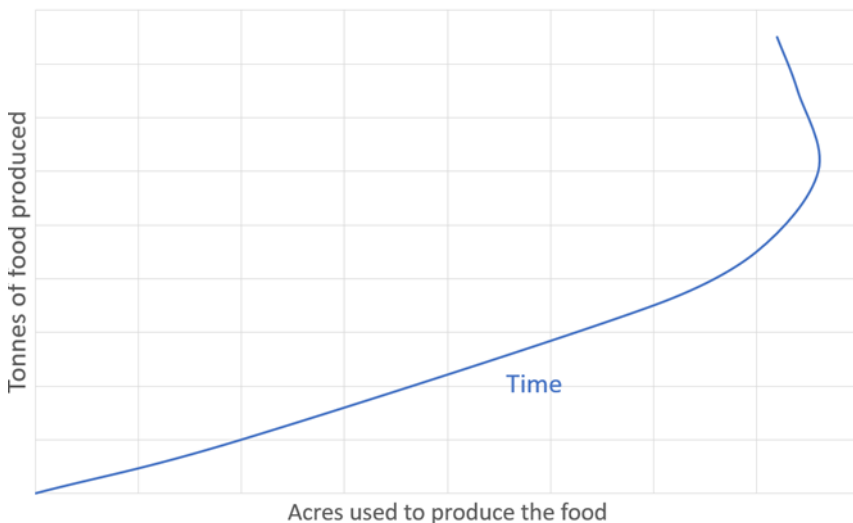


Figure 1: An illustrative example of the relationship between acres used to produce food over time.

1.1. DEFINING DIGITAL AGRICULTURE

Before we answer the question about reversing the curve, we need to define what we mean by “digital agriculture”. The digitalization of agriculture encompasses a spectrum of technologies, including precision agriculture, which gathers data for farm, crop and livestock management, as well as analytical tools for crop and farm management. Advancements in digital technology have heightened the demand for using data to improve and mitigate challenges faced by the agriculture sector (DeBoe & Jouanjean, 2019). This aligns with the current trend where digital technologies, such as the Internet of Things (IoT), artificial intelligence (AI) and data analytics are increasingly being leveraged to apply data in agriculture. These sophisticated and advanced Agriculture 4.0 technologies are a broad category encompassing various existing and developing technologies used in agriculture with the aim of optimizing various aspects of the value chain (Abbasi et al., 2022; Javaid et al., 2022).

However, a consistent definition of digital agriculture does not exist in the literature. See Appendix A for a discussion on the various definitions and what will be used in this report.

1.2. REPORT OBJECTIVES

As a part of its research Program on Digitalization of Agriculture in Alberta, the Simpson Centre is conducting a critical exploration of the regulatory ecosystem surrounding digital agriculture, undertaking an international jurisdictional scan to form the basis of developing a living and open-access database and juxtapose policies from diverse global regions with those existing in Alberta and Canada. This report investigates the Alberta, Canadian and Global digital agriculture sector to:

- Discern the efficacy of current regulations.
- Identify areas of enhancement
- Draw insights that can shape a progressive and adaptive regulatory framework.

Achieving these objectives will help the Simpson Centre at the School of Public Policy, University of Calgary, achieve its purpose to apply trans-disciplinary research to drive better policymaking and decision-making for a more sustainable, inclusive, and resilient agricultural industry, and ultimately, someday, reverse the curve.

1.3. CONTEXT

1.3.1. Approach: Leveraging STEEPLE

The intention of this report is to form the basis of developing a living and open-access database of current and historical federal, provincial and international policies and programs associated with data-intensive technologies and governance of the digital agriculture ecosystem. To start this database, 10 geographical regions (United States, Europe, China, India, Ukraine, Australia, New Zealand, Mexico, Canada and Alberta) were analysed using the STEEPLE framework to guide the research and ensure all regions in scope were assessed in a consistent and thorough manner. STEEPLE is a common analysis tool to assess the external environment of a particular topic, and stands for Social, Technological, Environmental, Economic, Political, Legal, Ethical.

1.3.2. Challenges and limitations

For jurisdictions that are not English-speaking nations and/or do not have English versions of their government websites, often the researchers have to rely on journals and/or news sources when learning about policies. It is also not clear how much detail was ever published by the governments from some of these jurisdictions (e.g., a policy may commit to certain outcomes but not explain how they would achieve it or how much funding is behind it). As such, some details were not as available as others or as much as desired.

This report primarily examines existing government policies across various jurisdictions. However, it is essential to recognize that policy influence extends beyond governmental directives alone. Factors such as non-profit organizations, international partnerships like the United Nations, and domestic innovation can also shape policy landscapes. Consequently, while our conclusions and recommendations are rooted in policy analysis, we acknowledge the broader spectrum of influences, both policy and non-policy, within each jurisdiction.

1.3.3. Report outline

The order of the regions in this report roughly reflects the level of intensity each jurisdiction places on digital agriculture policy (according to the author), with the exception of Alberta, which comes last due to the objectives of the report.

2. EUROPEAN UNION (EU)

Digitalisation is one of the cornerstones of the European Commission's priorities. The digitalisation of the European agricultural sector will empower farmers and rural communities with a new generation of technologies and will create transformative change for the EU's farming sector (European Commission, n.d.a). If any jurisdiction is going to reverse the curve first, the EU is a leading candidate.

2.1. THE COMMON AGRICULTURAL POLICY (CAP) AND DIGITISATION

The EU's Common Agricultural Policy (CAP), initiated in 1962, fosters a partnership between agriculture, society and European farmers. It aims to support farmers, enhance agricultural productivity, ensure food affordability, tackle climate change, sustainably manage natural resources, maintain rural landscapes and promote jobs in farming and associated sectors. As a uniform policy across EU countries, the CAP is managed and funded at the European level through the EU's budget.

CAP 2023-27 entered into force on January 1, 2023, marking the beginning of the implementation of the 28 approved CAP Strategic Plans in 27 EU countries (European Commission, n.d.d). A key objective of CAP is to modernise agriculture and rural areas through fostering and sharing knowledge, innovation and digitalisation (European Commission, n.d.b). Figure 2 depicts CAP's 10 high-level objectives (European Commission, n.d.c).



Figure 2: EU's Common Agricultural Policy's (CAP) 10 strategic objectives.

CAP, with a budgetary allocation of 264 billion Euros, promotes a comprehensive approach towards digitalisation for agriculture and rural areas, not only at farm level but also for the modernisation of the administration. For the first time, EU countries have designed digitalisation strategies as part of their CAP Strategic Plans, facilitating the advancement of digitalisation in agriculture and rural areas. These strategies are tailored to the unique situation of each country, exploring the potential of digital technologies to align with CAP-specific objectives and identify the requirements for promoting the adoption and sustainable use of digital technologies.

Overall, more than 274,000 farms are to be supported by digital farming technology, equipped to better adapt to new technical developments and ultimately, more productive without expanding the total land used to produce food. EU countries' plans promote digitalisation, focusing on critical areas such as the uptake of advanced technologies, including precision farming. CAP tools for digitalisation include:

- Investments in precision farming, smart villages, rural businesses and information and communications technology infrastructures like broadband
- Eco-schemes and agro-environment-climate commitments to support precision farming technologies optimising input use
- Sectoral interventions to purchase digital technologies at any stage of the supply chain, including knowledge exchange or monitoring of products' quality
- Farm advisory services on digital aspects in agriculture and rural areas, including the use of a Farm Sustainability Tool for Nutrients
- Cooperation to prepare and implement European Innovation Partnership (EIP) operational groups, local development and Smart Village strategies
- Support training for digital skills, increase awareness and knowledge on digital technologies and promote exchange of experiences with digital technologies (e.g. demonstration farms)

CAP is going to be the main agriculture-focused policy that will enable the EU to reverse the curve, but it's supported by other policies and programs too, some with more direct impact on agriculture than others.

2.2. THE DIGITAL AGENDA FOR EUROPE

European Union has adopted overarching digital transformation strategies, the primary focus of which was not exclusively on agriculture but may have had implications for agriculture. The Digital Agenda for Europe was launched in 2010 as a flagship initiative of the Europe 2020 Strategy. It underscored the pivotal role of Information and Communication Technologies (ICT) in realizing the objectives of Europe 2020 Strategy. The first "Digital Agenda for Europe: 2010-2020" reduced electronic communication prices and terminated roaming charges, improved internet connectivity with comprehensive basic broadband by leveraging mobile and satellite technologies, strengthened consumer protection in telecommunications through privacy and data protection regulations, which were later enhanced by a new data protection framework.

The second "Digital Agenda for Europe: 2020-2030" sets the broad objectives for Europe's Digital Decade, addresses the changes brought about by digital technologies, clarifies the vital role of digital services and markets. It prioritises quantum computing, blockchain strategies, AI, semiconductors (European Chips Act), digital sovereignty, cybersecurity, 5G/6G, European data spaces and global tech standards (Polluveer, Ratcliff, Martinello & De Bono, 2023). The Digital Agenda outlines key initiatives and sets the foundation for the Digital Compass, the Digital Decade Policy Programme 2030 and the Digital Europe Programme.

2.2.1. 2030 Digital Compass: the European way for the Digital Decade

The European Commission presented the Digital Compass in March 2021, which sets out measurable targets to foster digitalisation in the EU by 2030 and details actions for secure digital services and markets (European Council, 2024). The Digital Decade is primarily focused on digital transformation and data. It rarely speaks to agriculture specifically; however, almost every aspect of the strategy and policies within will support the digitization of agriculture. It sets specific digital targets and milestones to be reached by 2030 (European Commission, n.d.j). It puts digital skills and education at the forefront and is structured around four areas: Skills, businesses, infrastructure and public services (Polluveer, Ratcliff, Martinello & De Bono, 2023). A summary of the six initiatives that are most relevant to this report can be found in Appendix B.

2.2.2. The Digital Decade Policy Programme 2030 (DDPP 2030)

Also known as the "Path to the Digital Decade", the DDPP 2030 will facilitate Europe's digital transformation through a governance framework to help reach the 2030 digital objectives. The 2030 Digital Agenda targets and objectives will be pursued through an annual cooperation cycle, which will take stock of progress along priorly defined trajectories and KPIs. The programme also creates a new framework for multi-country projects that will allow Member States to join forces on digital initiatives (European Commission, 2023a).

2.2.3. Digital Europe Programme (DEP)

DEP is a policy instrument that provides the funding for the Digital Agenda initiatives. It supports, among others, the upscaling and deployment of innovative digital solutions across sectors with a multiyear budget of 7.5 billion Euros from 2021-2027. Measures relevant to supporting digitalization in agriculture, include (European Commission, n.d.e):

- Testing and experimentation facilities for AI in agri-food
-

- European Digital Innovation Hubs (EDIHs), including in agri-food
- Data spaces in the fields of agriculture and smart communities

Whether or not the various components of the Digital Agenda and its support structures mention agriculture specifically, it's apparent how they will impact the digitization of agriculture and as implementation progresses and how it is measured to determine how close the EU is getting to reversing the curve.

2.3. OTHER SUPPORT FOR DIGITAL AGRICULTURE

The EU supports research and innovation on agricultural and rural digital transformation as part of their broader funding programs.

2.3.1. *Horizon Europe*

Horizon Europe is the EU's key funding programme for research and innovation with a budget of €95.5 billion (European Union, 2022). Ongoing agricultural research projects and initiatives from Horizon Europe (under the Innovation Policy¹) collectively form the cornerstone of the EU's digital agricultural transition, driving sustainability, competitiveness and progress in the sector. They are pivotal in providing innovative digital solutions in many sectors, including agriculture, while empowering farmers to effectively utilise digitization technologies (European Commission, n.d.a). The following projects will share € 138M (European Commission, n.d.e):

- Smart solutions for agriculture
 - Projects ROMI and Pantheon have developed robotic and decision-making support solutions for microfarms and hazelnut productions
 - Projects ICAERUS, SPADE, and CHAMELEON will explore the use of drones as multi-purpose vehicles, including for agriculture
 - Projects CODECS and Quantifarm aim at assessing the impact of digital technologies in agriculture
- Sustainable digitalisation in rural areas
 - Projects Auroral and dRural are boosting rural economies through digital platforms, focusing on multi-sectoral digital services, including agriculture
 - Projects ICAERUS, SPADE and CHAMELEON will explore the use of drones as multi-purpose vehicles
 - A precondition for the digitalisation in rural areas is connectivity. The projects Xgain and COMNECT develop and assess innovative connectivity solutions and their cost-effectiveness
 - The project DESIRA has developed approaches to assess the status of digitalisation in rural areas, as well as the socio-economic effects of digitalisation and elaborated a policy roadmap
- Capitalizing on data

¹ [Innovation policy | Fact Sheets on the European Union | European Parliament \(europa.eu\)](#)

- To use the potential of data, it has to be systematically collected, stored and shared. The projects DEMETER and ATLAS have developed interoperability solutions in agriculture, allowing to link data from different sources and use it in different applications, e.g. decision-making support tools for farmers
- The project Divine will explore the application of the principles of the data economy in agriculture, and demonstrate, for example, the added value of data sharing in the sector
- The projects ScaleAgData, CrackSense, and AgriDataValue will add value to locally generated data, e.g. farm data, through the upscaling of data to higher levels with regard to the geospatial outreach

Having these projects commissioned is, in part, a recognition that some requirements for the digitization of agriculture are bigger than agriculture alone (i.e., to achieve a sustainable digital transformation of agriculture, government and other stakeholders need to consider what sustainable digital transformation in all rural areas must look like to support other sectors' needs too) (European Commission, 2021).

2.3.2. European Innovation Partnership for Agricultural productivity and sustainability (EIP-AGRI)

Given this program was active from 2012-2020, a number of EIP-AGRI Operational Groups² are currently developing solutions based on digital technologies to address practical problems or opportunities in the farming sector. Currently available data show that around 10% of Operational Groups work on precision farming or aspects related to the digital transformation more generally. At the EU level, a number of initiatives are underway, including (European Commission, n.d.e):

- EIP-AGRI Focus Group on Precision farming
- EIP-AGRI Focus Group on Digital tools for sustainable nutrient management
- New skills for digital farming
- Data revolution: emerging new business models in agri-food
- Digital Innovation Hubs: mainstreaming digital agriculture
- Multi-level strategies for digitising agriculture and rural areas
- Data Sharing: ensuring a fair sharing of digitisation benefits in agriculture

2.3.3. EU Code of Conduct

The EU Code of Conduct on agricultural data sharing, setup by a coalition of associations from the EU agri-food chain, provides guidance on the use of agricultural data, particularly the rights to access and the use of data. The code grants the data originator (the one who has created or collected the data) a leading role in controlling access to and use of data from their business. In this way, the data originator can benefit more from sharing the data with any partner that wishes to use their data. To fully reap the benefits of digital farming, sharing data between different partners in the agro-food chain must be conducted fairly and transparently (European Union, 2020).

It's evident that the EU is well on their way to a digitized agricultural economy and reversing the curve – but they are not alone.

² [Operational Groups | European CAP Network \(europa.eu\)](https://europa.eu)

3. AUSTRALIA

Another leading candidate to reverse the curve would be Australia, which currently has a strong pipeline of research and innovation resulting from collaboration with industry groups, Rural Research and Development Corporations (RDCs), agritech businesses and the education and research sectors. RDCs invest around \$800 million each year in agricultural innovation, with more than \$300 million of funding coming from the Australian Government and the remainder from industry levies (Australian Government – Department of Agriculture, Water and The Environment [AG-DAWE], 2022).

The Australian Farm Institute estimates that full adoption of digital tools by the agriculture sector could boost productivity by around \$20.3 billion each year (Australian Government – Department of Agriculture, Fisheries & Forestry [AG-DAFF], 2022).

3.1. THE DIGITAL ECONOMY STRATEGY 2030 (DES)

The DES vision is for Australia “to be a leading digital economy and society by 2030” (and Australia is not the only jurisdiction with a similar vision). Growth priorities include lifting the digital capability of small-to-medium enterprises and supporting modern and globally competitive industry sectors (including agriculture). It maps how Australia will continue to improve access to data, data sharing arrangements and data asset management and strengthen collaboration between government and industry. A key objective of the DES is for as many Australian businesses as possible to be operating at the digital frontier in their sectors, which can already be seen in agriculture.

In February 2021, one of the strategy’s first actions was launching the first round of the Australian 5G innovation initiative to fund small-to-large businesses to test and develop 5G uses, applications, services and products. Another more recent launch is the National Freight Data Hub, which was rolled out by the Australian Government following extensive consultation and testing.

The Agriculture 2030 package will drive productivity through innovation and encourage private sector investment. The digital technologies used in screening for pests that could harm Australia’s agricultural production will be enhanced and the capability of the sector to adopt digital tools will be improved (Australian Government, 2021).

3.2. DIGITAL FOUNDATIONS FOR AGRICULTURE STRATEGY (DFAS)

While the DES is a broad strategy covering many sectors, the DFAS (released April 2022) discusses Australia’s agriculture sector’s specific needs and priorities. It sets the foundation for development and widespread uptake of digital technologies across Australia’s agriculture, forestry and fisheries industries, as well as a national, whole-of-sector approach that is focused on uptake and the entire supply-chain.

DFAS outlines five key action focus areas: leadership, skills, data and governance, opportunities and value proposition and connectivity and infrastructure. There are many strategies, programs and plans being implemented under each of these focus areas, all with varying mandates surrounding the broader vision of a digital leader in agriculture by 2030 and

the relevant details are summarised below (Australian Government – Department of Agriculture, Water and The Environment [AG-DAWE], 2022³).

First, there is one topic that incorporates all five key action focus areas, which is the **National Centre for Digital Agriculture and Digital Officers in the Innovation Hubs**, which is an Australian Government’s \$30 million investment in the Innovation Hubs to provide a unique pathway to bridge the gap between the opportunities arising from digital agriculture and the current barriers to their adoption on the ground. New digital officers will be funded in each of the eight existing Innovation Hubs along with extension activities to:

- **Increase awareness.** Help to farmers understand the value of digital technologies and data to their businesses and other businesses along the supply chain.
- **Increase literacy.** Support farmers and agribusinesses to improve their digital literacy and confidence in using digital technologies.
- **Increase trust.** Strengthen stakeholder’s confidence in data and accessing connectivity solutions, including using data to make informed business decisions and understanding how data is used by others in the supply chain.

These hubs will be beneficial to Australia’s pursuit of reversing the curve, but so too will all the programs and strategies within the various pillars of DFAS listed below.

3.2.1. Leadership

The first of the five pillars of the DFAS is Leadership. The overarching theme for Leadership is to enhance connection and coordination across the sector, encourage pooling of resources and provide a clear plan to unify stakeholders around collective long-term goals.

| | |
|---|---|
| The Artificial Intelligence (AI) Action Plan⁴ | It sets out the steps being taken for Australia to become a global leader in developing and adopting trusted, secure and responsible AI, backed by a \$124.1 million government investment. |
| The Critical Technologies Policy Blueprint⁵, Action Plan and List | Includes tangible actions designed to protect and promote the 63 current and emerging technologies, such as AI, seen as critical to Australia’s future and agricultural competitiveness (Australian Government – Department of the Prime Minister and Cabinet, 2021). The Simplified Trade System will modernise outdated ICT systems and Australian agricultural producers and exporters will benefit from the harmonisation of traceability standards and data, maximising exporters' ability to meet market demands and receive premium prices for their quality produce (AG-STSITF, 2022). |

³ This is also the source for anything else in this section, unless otherwise specified.

⁴ [Australia’s Artificial Intelligence Action Plan | Department of Industry Science and Resources](#)

⁵ Read the blueprint here: [Blueprint for Critical Technologies \(industry.gov.au\)](#)

Smart Farming Partnerships

Australia’s Smart Farming Partnerships, a component of the National Landcare Program, encourage the widespread uptake of digital agriculture to help farmers and land managers improve productivity and protect soils, water and vegetation. Over six years, \$57.5 million is being invested. Two direct measures are active:

- **Direct measure 1: growAG** is a digital platform that enables RDCs, universities and private organisations to showcase their agricultural research and engage with investors in Australia and overseas. Led by AgriFutures Australia, the platform plays a role in connecting organisations and fostering commercialisation outcomes.
- **Direct measure 2: evokeAG** is an agrifood tech event that connects the agrifood innovation community across Asia Pacific and the world. The event gives start-ups a forum to pitch their potential, farmers the opportunity to share their experiences and scientists a chance to showcase their discoveries.

To begin to reverse the curve, countries are going to have to show leadership in various ways, including funding programs that encourage the innovation and behaviours required to succeed in producing and consumer more with less land, and Australia is doing just that.

3.2.2. Skills

The second pillar of the DFAS is to deliver the skills and expertise needed by both the current and future workforce to modernise the sector, which includes attracting and retaining highly skilled people from the science, technology, engineering and mathematics (STEM) disciplines to help grow digital technologies.

| | |
|--|--|
| The Digital Skills Cadetship Trials | Government works with industry to trial tailored training alongside on-the-job experience provided by host employers to increase the number of Australians with high-level digital skills, as part of the Digital Economy Strategy. |
| The Cyber Security Skills Partnership Innovation Fund | Increase the quality and quantity of cyber security professionals in the Australian workforce by supporting innovative collaboration projects between industry and education providers. In the first round of funding, La Trobe University received \$2.35 million to increase high school student awareness of cyber security skills and training. |
| The Digital Readiness Assessment Tool | This tool helps businesses measure their readiness and capability for free, including their digital skills, against a range of metrics. To ensure there is a sustainable pipeline of graduates, the government is investing \$47.3 million over a six-year period, beginning in 2021–22. This will support two programs of competitive national scholarships – the Next Generation Emerging Technology |

Graduates Program and the AI Graduates Program. Two tools in use in agriculture are:

- **Australian Agricultural Workforce Digital Capability Framework and Self-Assessment Tool** provides the analysis and framework for education providers to develop a curriculum to meet future demand for digital skills in the agriculture industry (Price, 2021).
- **Australian Agriculture Digital Maturity Index and Self-Assessment Tool** is the first digital maturity index and assessment tool specifically for agriculture in the world (AgriFutures Australia, 2019).

National Agricultural Workforce Strategy

Along with the Australian Government Roadmap, this strategy’s focus is on attracting, retaining, upskilling and modernising the agricultural workforce. They set a path to ensure the agriculture industry has access to sufficient and appropriately skilled workers.

AgATTRACT

This is a skills development initiative that aims to shift perceptions of agriculture and agricultural work by showcasing the diverse career opportunities being offered. It also includes the AgCAREERSTART pilot program, which is a structured employment program designed to help young Australians start a career in agriculture during their gap year.

Next Generation Emerging Technology and AI Graduates Program

Will help drive the competitiveness of Australian businesses and ensure local talent is available to fill high-skilled jobs in Australia, including in the agriculture sector. The government’s investment of \$47.3 million will help ensure a sustainable pipeline of home-grown talent.

3.2.3. Data and Governance

The third pillar of the DFAS is data and governance, which is meant to maximise data use, ensuring good data management, common data standards, and interoperability. The Australian Government is committed to improving the understanding and trust around the storage, management and sharing of data across the economy, with a range of initiatives already in place. The DES will also play an important role in advancing the application of data and governance.

The Consumer Data Right

This economy-wide framework will provide greater competition in the marketplace by giving end-users the right to share their data between the service providers of their choosing. The roll-out will go sector-by-sector, eventually including agriculture.

| | |
|--|--|
| The Australian AgriFood Data Exchange | This industry-led project assesses the methods and benefits of creating an interconnected data highway for Australia’s agrifood value chain. The Australian Government is contributing \$600,000 to the pre-business case experiment phase, alongside funding and support from universities, RDCs, state governments and industry organisations. |
| Australian Farm Data Code | This voluntary code of conduct provides a framework to create comfort for farmers in how their data is used, shared and managed, and to enable farmers to compare providers and inform negotiations about data policies. The code is led by the National Farmers’ Federation, with \$400,000 in funding from the Australian Government to support the expansion. |
| National Soil Package | <p>The National Soil Package is an Australian Government \$214.9 million investment consisting of many projects that aim to capture historical and new soil data and make it publicly available, including:</p> <ul style="list-style-type: none"> • \$5.9 million to implement the National Soil Strategy, including the development of a National Action Plan. • \$54.4 million for a two-year Pilot Soil Monitoring and Incentives Program where land managers will be able to access low-cost soil sampling and Australasian Soil and Plant Analysis Council (ASPAC)-certified testing in exchange for sharing their data. • \$15 million to develop the Australian National Soil Information System to store soil data, track and report trends and changes in soil health, and be used to monitor the impact of land management practices and environmental shocks over time. • \$20 million over four years for a Soil Science Challenge Grants Program to address fundamental gaps in soil science and improve our understanding of how to better manage soil. |
| The National Stewardship Trading Platform | This is part of the Australian Government’s \$66.1 million Agriculture Biodiversity Stewardship Package , which was recently granted an additional \$25 million. The package aims to create new stewardship market opportunities, diversity incomes and enable private sector investment in farm biodiversity. |

Data is the way of the future for agriculture and is the enabler of the digitization of agriculture; data is critical to reversing the curve and Australia is putting data at the forefront.

3.2.4. Opportunities and Value Proposition

The fourth component of the DFAS is opportunities and value proposition, which is to help producers understand and realise the benefits from digitising their businesses, ensuring appropriate and agile regulation while fostering faster commercialisation, which includes pathways for businesses and researchers to capitalise on AI and commercialisation opportunities.

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| Catalysing the AI Opportunity in our Regions Program | This program is specifically aimed at regional industries, including agriculture, to deliver projects using AI technologies. The program will provide \$12 million over five years to support the development, implementation and demonstration of real-world applications of AI technologies. |
| University Research Commercialisation Action Plan | A \$2.2 billion Australian Government investment to coordinate and incentivise the translation of Australia’s world leading research for commercial benefit, including doubling the value of food and beverage manufacturing. |
| Business Research and Innovation Initiative | Provides funding to businesses to help solve policy and service delivery challenges using digital technologies to streamline or enhance compliance processes. |
| Producer Technology Uptake Program | Led by AgriFutures, this pilot program aims to deliver practical, on-ground technology adoption to farmers. It is currently delivered in partnership with existing producer networks such as farming systems groups and targets ‘early majority’ technology adopters. |
| Busting Congestion for Agricultural Exporters | The Australian Government’s \$328 million package that will support agricultural exporters to get products to market faster. In addition, the government has committed an additional \$127.4 million in the Digital Services to Take Farmers to Market measure to continue the digital transformation of our agricultural export systems. |
| Agricultural traceability investments | Worth \$68.4 million, this funding will build on the already strong traceability frameworks in place, especially around food safety, provenance and biosecurity. An additional \$20.1 million investment will also help support on-farm biosecurity traceability. |

3.2.5. Connectivity and Infrastructure

The fifth and final component of the DFAS is connectivity and infrastructure, which is aimed at ensuring agricultural businesses understand their connectivity options and can access the infrastructure they need. The Australian Government is committed to improving awareness among agricultural businesses of the availability of existing telecommunications technology solutions, including solutions to extend connectivity across entire properties, all of which is critical to leveraging data and reversing the curve.

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|---------------------------------|--|
| 5G Innovation Initiative | Provides \$40 million in competitive grants to help Australian businesses test and develop 5G technologies in key industries, including agriculture. |
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| Emerging Aviation Technologies Partnerships Program | Also, a part of the Australian Government’s DES, this program provides \$32.6 million in funding to support strategic partnerships with industry, using emerging aviation technology such as drones to address community needs. |
| The Connecting Regional Australia (CRA) initiative | An \$812 million multi-purpose investment to expand mobile coverage, target specific and localised needs, enhance resilience, trial emerging technologies, boost Indigenous connectivity and foster affordability, as well as improve community digital awareness. |
| Regional Connectivity Program | Funds ‘place-based’ telecommunications infrastructure projects to improve digital connectivity across regional, rural and remote Australia. Under Round 1 of the program, \$118 million has been allocated to address local digital priorities in 132 regional areas. |
| Strengthening Telecommunications against Natural Disasters | A \$37.1 million Australian Government investment to improve the resilience of Australia’s telecommunications networks in bushfire and natural disaster-prone areas. This includes funding for the hardening of mobile networks. |
| Regional Tech Hub | Assists people who live and work in regional, rural and remote parts of Australia to realise the benefits of being digitally connected. The Government is providing an additional \$5 million to expand and continue the Regional Tech Hub to support better consumer awareness. |

4. NEW ZEALAND

While not quite as focused on the digitization of agriculture as Australia and the EU, New Zealand is a close third. However, New Zealand’s focus is a little more on the AgTech side of the industry. That being said, their focus on the digitization of agriculture and AgTech is likely largely space-driven. New Zealand doesn’t have a lot of arable land they can turn into agricultural land; they are almost forced to try to reverse the curve.

4.1. FIT FOR A BETTER WORLD

In 2012, the New Zealand Ministry of Agriculture and Forestry, which dealt with matters relating to agriculture, forestry, and biosecurity, became part of the newly formed Ministry of Primary Industries (MPI), within which there are many environmental and agricultural-related programmes. However, where many of such programs could seemingly benefit from digitization, they don’t talk about digital solutions or technology much or at all.

One example of this is **Fit for a better world**, which is a roadmap developed by MPI to accelerate the economic potential of the primary sector. It sets out actions to bring together opportunities the Government considers will accelerate the productivity, sustainability and inclusiveness of the primary sector, to deliver more value for all New

Zealanders (NZG-MPI, n.d.b). While it's objectives and purpose do not mention digital agriculture specifically, some of its implementation programs are digitally focused. For example, in planning for "Connected Communities", good connectivity provides opportunities for agritech technologies, digital farm data management, robotics, automation and mechanisation. The New Zealand Government has signed an agreement with mobile operators where in return for allocation of the 3.5 GHz spectrum, work to provide 5G to around 55 rural and regional towns will be accelerated. The mobile operators will also contribute \$72 million for further projects to improve rural digital connectivity (NZG-MPI, 2023).

4.1.1. Sustainable Food and Fibre (SFF) Futures

SFF is a funding programme from MPI that supports innovative projects that will create more value from the food and fibre industries. They can range from small, one-off initiatives requiring a small grant, to long-running, multi-million-dollar partnerships. While this funding program doesn't call out digital solutions specifically, projects advancing the digitization of agriculture would most likely qualify (NZG-MPI, n.d.c).

Within the SFF Futures is the Sustainable Farming Fund (SFF); however, the SFF has been around since 2000. It supports applied research and projects led by farmers, growers, and foresters.

In 2018, MPI launched a pilot initiative called SFF Tere to support investment in smaller SFF projects (sub \$100,000). The aim of SFF Tere is to streamline the application process, making it quicker and easier for people to apply for investment and speeding up the decision-making process (NZG-MPI, n.d.g).

4.1.2. digital Farm Environment Plans (dFEPs)

MPI set aside NZ\$493,500 from the SFF Futures to contribute to a digital farming research project expected to cost NZ\$823,500. The project is led by AgriTechNZ, a non-profit trust and membership organization that includes New Zealand producers, growers, exporters, retailers and consumers focussed on sharing trusted data and processes among its members to move agriculture in New Zealand (New Zealand Government – Beehive, 2022). AgriTechNZ states:

Our food and farming systems are faced with both challenges and opportunities in food security, climate and environmental impact. Digital agriculture or 'smart farming' represents a set of tools to enhance practices for the benefit of farmers and consumers (OpenGovAsia, 2022).

Farm Environment Plans (FEPs) are a pivotal tool to identify and take action on environmental risks on-farm and demonstrate progress on environmental objectives. ICT solutions aim to fast track the delivery of a digital solution for FEPs. As a result, farmers and growers will be able to share environmental compliance data through the same toolsets that are used for regular farm management tasks. Creating a digital option for FEPs means managing farming decisions and regulatory requirements will be far more efficient (New Zealand Government – Beehive, 2022).

4.1.3. AgResearch

AgResearch is one of the seven Crown Research Institutes in New Zealand. Its purpose is to enhance the value, productivity and profitability of New Zealand's pastoral, agri-food and agri-technology sectors through effective science. It is responsible for delivering innovative science and research outcomes specifically for agriculture (AgResearch, n.d.). Some relevant topics include:

- **Land and Water**, a "Science Challenge" funded by the Ministry of Business, Innovation and Employment (MBIE). Solutions include an interactive tool offering insight into climate change impact on plant diseases, a

streamlined land and water information platform, and an innovative data sharing trial with Beef + Lamb Genetics (Our Land and Water, 2024).

- **eResearch-based Digital Agriculture platform** will interface cyber-technologies with biological systems across supply chains to enable hyper-transparency. It will enable the integration of the research process in systems-based science, making it significantly more effective. The platform will encompass capabilities that interface biological systems with physical and cyber-physical systems such as: distributed sensory networks; Internet of Things (IoT); sensing technologies; automation; robotics; electronics; embedded systems; Blockchain and emerging technologies (AgResearch, 2019).
- **NZ Bioeconomy in the Digital Age** is a programme that seeks to harness the emerging power of digital technologies to enable the transformation of New Zealand food systems (AgResearch, 2019).

4.1.4. Extension Services Programme

This programme funds farmer-led catchment projects that support sustainable land use and improve economic, environmental and farmer wellbeing outcomes, but there is no specific mention of digital or technology solutions (New Zealand Government – Ministry for Primary Industries [NZG-MPI], n.d.a).

4.1.5. Water availability and security

Another example is MPI's focus on water availability and security, working to give farmers and growers more options for using their land. But there is no mention of digital or technology solutions (NZG-MPI, n.d.d).

4.1.6. The way MPI operates

Ultimately, what is found with New Zealand and the digitization of agriculture is two-fold:

1. A large focus is on the agritech side of the business
2. Environmental issues like climate change / emissions take precedence over farmer productivity

Also, funding for agriculture isn't always part of a programme, policy or strategy, per se (or at least it's not obvious). For example, MPI has funding available for various projects looking at land and soil health, where digital agriculture technology is being leveraged, but there isn't a program name to list this under (NZG-MPI, n.d.h).

4.2. AGRITECH INDUSTRY TRANSFORMATION PLAN (ITP)

The original Agritech Industry Transformation Plan (ITP) was launched in July 2020 and set out the steps that government and industry would take to accelerate the growth of New Zealand's agritech sector. Through Budget 2020, Government committed NZ\$11.4 million to support the Agritech ITP. It aims at scaling up the agritech sector, building on its existing high-value proposition.

The refreshed 2022 Agritech ITP proposes an updated vision of 'a globally-recognised agritech sector creating solutions for a better world.' It aims to accelerate the growth of New Zealand's agritech sector to reach NZ\$8 billion by 2030. The ITP aims to develop a smart agritech innovation ecosystem that attracts international attention and investment.

4.2.1. Focus Area 3: Enabling a smart innovation ecosystem

A key enabler for the success of New Zealand's agritech sector will be its ability to work together as a smart innovation ecosystem. This includes (New Zealand Government, 2023):

- The connectivity of productive land to enable remote technologies or analysing existing data collection from satellite and on-farm technologies that could be better utilised across the system
- The standardisation of key farming data, which will be a regularly-maintained and updated public repository of standardised farming data (to act as a guide to the agritech sector when developing products and solutions)
- Increase in the number and availability of ‘smart farms’ that enable the testing of agritech solutions
- Clear pathways from developing and trialling technologies, through to customer acquisition and scaled deployment domestically and internationally
- The agritech sector’s growth must be enabled by the appropriate ‘building blocks’ that underpin it, including physical infrastructure (e.g., internet connectivity and research facilities) and soft infrastructure (e.g., human capital, institutions, and regulations)
- Create the conditions for a digital ecosystem in which a food and fibre producer can choose their preferred technology to manage their farm planning and share it with their other chosen digital tools
- Government announced the investment of \$100m into a Business Growth Fund, aiming to help fill a gap in the capital market for small and medium sized enterprises (SMEs) that require growth capital not available through current market providers.

4.2.2. Farm2050

The Farm2050 global initiative was launched in 2014 to solve the challenges of feeding a global population of 10 billion people (by 2050) with deep technology solutions that create greater sustainability and nutrition outcomes through supporting AgTech entrepreneurs and startups (Farm2050, n.d.a). The ITP has funded Farm2050 trials with \$850,000 (New Zealand Government, 2023).

4.3. NEW ZEALAND GOVERNMENT INSTITUTES

As New Zealand's innovation agency, Callaghan Innovation fosters R&D by providing funding and scientific expertise while promoting collaboration between researchers, scientists, and industry to commercialize impactful ideas. Collaborating with New Zealand Trade and Enterprise (NZTE), they facilitate interactions between local agritech companies and global experts. NZTE, through initiatives like the New Zealand Agritech Story, promotes the adoption of digital technology in agriculture domestically and globally, co-creating pilot programs with partners like Callaghan Innovation and Agritech New Zealand to advance digital agricultural innovation (New Zealand Trade & Enterprise, 2019). The New Zealand Institute for Plant and Food Research Limited focuses on sustainable food production, utilizing data and artificial intelligence to enhance various aspects of the food production chain (Plant & Food Research Institute, n.d.).

5. CHINA

China is responsible for producing roughly 20% of the world’s food, making it the largest agricultural economy globally. Agriculture has always been a driver of innovation in China, and the goals are to achieve a self-sufficient food supply, work towards increasingly centralised production and improve the quality of the products. Policymakers fully understand that the future of China’s agriculture sector lies in agricultural modernisation, and the key to advancing agricultural modernisation lies in the development of technology (Van’t Klooster, 2022). Interestingly, smallholder farmers account for as high as 80% of food production in China. Many of these smallholder farmers are older and

received less formal education, making it more difficult for them to adopt technology without support. The availability and accessibility of internet infrastructure is also a potential barrier for these farmers (World Economic Forum, 2022).

There are multiple plans and policies discussed below, but there is no clear link between any of them; one may build off another, but none appear to be “under” or within any of the others.

5.1. 2019-2025 DEVELOPMENT PLAN

On January 20, 2020, the Ministry of Agriculture and Rural Affairs and the Office of the Central Cyberspace Affairs Commission jointly released the 2019-2025 Development Plan. The goal related to agriculture is to advance the digitalization of agricultural development and rural governance amid the country's ongoing plan toward rural vitalization. It envisions that by 2025:

- Significant progress will be made in digital agricultural and rural development, offering strong support for the Digital Rural Development Strategy (DRDP)
- Digital technology will see faster integration with systems involving agricultural industry, production and operation, with the proportion of agricultural digital economy greatly increased
- The agricultural digital economy should account for 15% of China's agriculture value-added, with internet access expected to cover 70% of rural areas

The plan requires efforts to strengthen research on blockchain standardization in the agricultural sector and promote the innovative application of blockchain technology in agricultural resources monitoring, quality and safety traceability, rural financial insurance and transparent supply chain. Research will also be carried out on 5G technology application in the agricultural sector, amid efforts to establish and improve the intelligent agricultural technology system led by 5G (People's Republic of China – The State Council [PRC-SC], 2020a).

5.1.1. *The Development Plan for Digital Agriculture and Rural Areas (2019-2025) (DPDARA)*

This DPDARA is a cross-sectoral policy document that was prepared to implement the Opinions of the CPC Central Committee and the State Council on Implementing the Rural Revitalization Strategy, the Strategic Plan for Rural Revitalization (2018-2022) and the Outline of Digital Rural Development Strategy (ODRDS); and to accelerate development of precision agriculture and rural production and administration, smart management services and rural government digitization. The DPDARA is part of the Development Plan 2019-2025 and has the following goals for agriculture:

- Expansion of digital technologies in agriculture and rural areas by 2025
- Launch the data collection system for agriculture and rural areas and lay the groundwork for the Space/Aerial/Ground observation network, fundamental data resources and the cloud platform for agriculture and rural development
- Accelerate integration of digital technology with the industrial, production and management systems in agriculture
- Substantially increasing the share of digital agriculture

Subsequently, China released the Digital Rural Development Action Plan for 2022–2025, which:

- Emphasizes upgrading digital infrastructure and developing smart farming in rural areas
-

- Outlines policy incentives designed to encourage the adoption of digital technologies, which could include financial subsidies, technical support and favourable regulations
- Encourages research and innovation in digital agriculture technologies (Cui & Wang, 2023)
- Sets forth programs to improve digital literacy among farmers
- Enhances rural financial service systems to facilitate the purchase of digital technologies by providing farmers with access to credit and other financial services (Zeng et al., 2024)

5.2. 14TH FIVE-YEAR PLAN 2021-25 FOR NATIONAL ECONOMIC AND SOCIAL DEVELOPMENT

Although separate from the 2019-2025 Development Plan, the 14th Five-Year Plan is a comprehensive blueprint that builds upon the Development Plan and outlines the country's strategic goals and initiatives for the next five years. The plan is high-level and while it isn't directly tied to formal agriculture policies, it clearly sets the vision of the agricultural and rural development that past and subsequent policies are working towards.

Rural development and agriculture modernisation have been long-time government priorities, but this is the first five-year plan that deals with the concept of "rural revitalisation". It calls for China to pursue: "a new type of industrial-agricultural-urban-rural relationship featuring mutual promotion of industry and agriculture, complementary urban and rural development, coordinated development and common prosperity and to accelerate the modernization of agriculture and rural areas" (United Nations Development Programme, 2021). Some relevant components of the plan are (CSET, 2021):

- Develop advanced and applicable agricultural machinery such as intelligent high-horsepower tractors, precision (no-tillage) planters, spray bars and spray grates, ditching fertilizer applicators, high-efficiency combine harvesters, fruit and vegetable harvesters, sugarcane harvesters, and cotton pickers and develop special agricultural machinery for high-efficiency agricultural production in hilly and mountainous areas
- Accelerate the development of smart agriculture and advance the digital transformation of agricultural production, operation, and management services
- Promote precision seeding, precision fertilization and pesticide application and precision harvesting of field crops
- Strengthen research on agricultural superior seed technology, promote the industrialized application of bioengineered breeding in an orderly manner and cultivate leading enterprises in the seed industry with international competitiveness
- Improve the agricultural S&T innovation system, develop innovative agricultural technology extension service methods and build smart agriculture.

5.2.1. *Digital Village Development Strategy (DVDS)*

Like many of the plans and strategies in China that relate to rural communities and agriculture, the Digital Village Development Strategy is being executed in support of more than one government policy. Primarily, it supports the 14th Five-Year Plan 2021-25 for National Economic and Social Development but it also helps execute on the DPDARA. The DVDS aims to narrow the gap between urban and rural areas, accelerate the penetration of the digital economy into rural areas, and achieve sustainable development in rural areas.

Since the release of the DVDS in 2019, there has been a lot of progress achieved in the development of digital villages. Various regions have gradually launched digital village construction, and 117 digital village pilot areas were identified in 2020 (Zhao, W., Liang, Z. & Li, B., 2022). The Central Cyber Commission of China and the Ministry of Agriculture and

Rural Affairs' Department of Market and Informatization jointly released the China Digital Village Development Report in March 2023, with the following noted (Deutsch-Chinesisches Agrarzentrum, 2023) ⁶:

1. Improvements in digital village infrastructure: The number of rural netizens has reached 293 million and rural internet coverage reached 59% by June 2022. The number of 5G stations in China reached 1.9 million, covering 96% of counties and towns in the country.
2. Progress in smart agriculture: Overall informatization⁷ of agriculture in China reached 25.4% as of 2022.

5.3. THE NATIONAL PLAN FOR RURAL INDUSTRIAL DEVELOPMENT (2020-2025)

Also closely related to the DPDARA and the 14th 5-year Plan, the 2020-2025 National Plan for Rural Industrial Development was issued by China's Ministry of Agriculture and Rural Affairs in 2020 to lay the groundwork for modernizing agriculture and achieving all-round rural revitalization, optimize the rural employment structure and broaden channels for increasing farmers' income and strengthen rural industry productivity. While funding or other interventions could not be found within this plan, success and other measures include (PRC-SC, 2020b):

- The agricultural product processing industry will achieve a revenue of RMB 32 trillion, and its output value versus that of the entire agricultural sector will reach 2.8:1. Agricultural tourism will see a total of over 4 billion visits every year with a revenue of more than RMB 1.2 trillion. The output value of crop production, forestry, livestock and fisheries sectors and their complementary activities will amount to RMB 1 trillion, so will be the online sales of agricultural products
- Provide farmers with more employment and entrepreneurship opportunities, as well as value-added benefits of the industrial chain, by directing more resources to rural areas and accelerating cross-sector allocation of productive factors between agriculture and other modern industries.

5.4. RURAL AND AGRICULTURAL DIGITALIZATION DEVELOPMENT PLAN FOR 2019-2025

Also, a standalone policy, but also in support of the previously discussed plans and strategies, the Ministry of Agriculture and Rural Affairs and the Central Cyber Security and Information Committee of China jointly published the "Rural and Agricultural Digitalization Development Plan for 2019-2025" in December 2019, which provides a blueprint for digitalization of agriculture and rural areas. The plan calls for efforts to accelerate the development of rural industries and lay a solid foundation for the modernization of agriculture. The plan outlines five goals (Rouzi, 2020):

1. Establish a basic data source system
2. Improve digital agriculture productivity
3. Build a digital agricultural rural service system, an intelligent monitoring system for rural human settlements, and a digital rural governance system
4. Accelerate the development of agricultural artificial intelligence research development

⁶ Note that formal government documentation of a "Digital Village Development Strategy" could not be found; however, other sources reference it and digital villages are discussed heavily in the "Digital Rural Development Plan" (https://www.gov.cn/zhengce/2019-05/16/content_5392269.htm). It's possible these documents are not readily accessible due to language barriers or the specific platforms where they are published.

⁷ The informatization rate is a comprehensive indicator, including the use of digital technology in production, harvest, processing, retailing and data management.

5. Implement major national agricultural and rural big data centers, agricultural and rural aerial-ground integrated observation systems, national digital agriculture and rural innovation and other major engineering projects to enhance the support capacity of digital agriculture and rural development

5.5. NO. 1 CENTRAL DOCUMENT

With all of these integrated plans and policies that range from 4-7 years in length, the Chinese government releases an annual policy update to ensure its citizens and other stakeholders understand what the current policy priorities are in the country and anything that might have changed for the upcoming year. This is the first policy statement released by China's central authorities each year; it is seen as an indicator of policy priorities. Work on agriculture and rural areas has been high on the agenda since 2004 (PRC-SC, 2023).

6. INDIA

India is the world's second-largest food producer. Agriculture employs over 42% of the labour force (2019), contributes 19.95 of the GDP (2020-21), and provides food security for about 1.3 billion people. Hence, technology and the digitalisation of agriculture play the role of a catalyst to improve and increase production. According to the NITI Ayog, a public policy think tank, research on artificial intelligence, agriculture must expand at a rate of 4% or higher right now to maintain an annual growth rate of 8-10%. Digitisation is crucial for achieving this level of success and yet complicated should the goal eventually be to reverse the curve. NITI Aayog predicted in a report that by 2025, AI in agriculture would be worth \$2.6B and rise at a pace of 22.5% CAGR (InvestIndia, 2022).

6.1. DIGITAL AGRICULTURE MISSION 2021–2025

Instituted by the Ministry of Agriculture and Farmers Welfare, the purpose of this program is to encourage and speed up projects based on cutting-edge technologies, including AI, blockchain, remote sensing, robots, and drones. Five Memorandum of Understandings (MoU) were signed to advance digital agriculture through pilot projects with various companies.

Microsoft and the Indian government have teamed up to support India's small-holder farmers by running a pilot programme called 'Unified Farmer Services Interface'. The alliance aims to boost farmers' incomes through improved price management and increased agricultural yield using AI sensors. The collaboration would accelerate the use of AI in farming. In June 2021, The Ministry of Agriculture and Farmers Welfare signed an MoU with Microsoft to run a pilot programme for 100 villages in 6 states. Under the MoU, Microsoft will create a 'Unified Farmer Services Interface' through its cloud computing services. This is a major part of the ministry's future plan to create 'AgriStack' - a unified platform to provide end-to-end services across the agriculture food value chain to farmers. For this the government is planning to create unique farmer IDs for farmers across the country to integrate it with various government schemes and create digital agricultural ecosystems (India Brand Equity Foundation, 2021).

6.2. PARTNERSHIPS WITH WORLD ECONOMIC FORUM

6.2.1. *Agricultural Data Exchange (ADeX)*

India's first agricultural data exchange was launched in Hyderabad on August 11, 2023. ADeX is a collaboration between the Government of Telangana, World Economic Forum, and the Indian Institute of Science (IISc). It serves as a digital public infrastructure (DPI) for the agricultural sector.

ADeX is an open-source, open-standard and interoperable public good that democratizes access to data and enables the public and private sector to build applications and deliver services that benefit society. The software platform facilitates secure, standards-based exchange of data between agricultural data users (e.g., agri application developers) and agricultural data providers (e.g., Government Agencies, Private Companies, NGOs, Universities, etc.) (Indian Institute of Science, 2023).

6.2.2. *The Artificial Intelligence for Agriculture Innovation (AI4AI)*

This initiative was launched in August 2020 by the World Economic Forum's Centre for the Fourth Industrial Revolution India, in active collaboration with the Government of Telangana (a state in India) and support from India's Ministry of Agriculture, the National Institution for Transforming India (NITI) Aayog and the Ministry of Electronics and IT.

Conceived as an umbrella programme that seeks to create value across the entire agriculture ecosystem through the deployment of a wide range of emerging technologies in a way that can scale up across India and provide insights and models for other emerging economies, the vision of AI4AI is "to transform the state of agriculture by deploying emerging technologies in an inclusive and sustainable way." The key objectives of AI4AI are to (World Economic Forum, 2021b):

- Enhance digital and financial inclusivity among smallholder farmers
- Build trust and transparency through quality and traceability
- Protect the environment from unsustainable practices
- Establish sustainable farm incomes

Saagu Baagu

One of the most successful implementations of the AI4AI initiative is the Saagu Baagu pilot, developed in partnership with Telangana state government. The project has substantially improved the chili value chain for more than 7000 farmers. Farmers participating in the programme saw a 21% increase in chili yields per acre, a 9% reduction in pesticide use, a 5% decrease in fertilizer usage, and an 8% improvement in unit prices due to quality enhancements. As such, farmers have seen their incomes effectively double. Due to this success, in October 2023, the Telangana government expanded Saagu Baagu's scope, which now aims to impact 500,000 farmers, encompassing five different crops across ten districts (World Economic Forum, 2024).

6.3. OTHER PLANS AND PROGRAMS UNDER THE MINISTRY OF AGRICULTURE & FARMERS WELFARE

The Ministry of Agriculture & Farmers Welfare has created digital programmes and applications in order to boost technology adoption among farmers.

6.3.1. National e-Governance Plan in Agriculture (NeGPA)

The National e-Governance Plan (NeGP) was initiated in 2006 and since then has launched Plan 2.0, a program within Digital India. Initially launched in seven selected Indian States in 2011, this program was extended to a second phase to cover all the States starting in 2014. NeGPA, a subset of NeGP, aims to achieve rapid development in India through use of ICT for timely access to agriculture related information for the farmers. To start with, for the use of AI and ML, Big Data Analysis, Internet of Things, etc. in agriculture, NeGPA guidelines were revised in 2020. Under the revised NeGPA guidelines, funds from 2021-22 will be released to the States only for the projects involving use of modern information technologies such as AI and ML, Block Chain Technology, Internet of Things, Robotics etc., and for customization/shifting of web and mobile applications already developed by the States, to the platform to be developed using digital technologies mentioned above.

As a part of NeGPA initiative, the government has developed one Stop Window-Farmers Portal (www.farmer.gov.in) for dissemination of information on various agricultural related matter including, seeds variety, Storage Godown, Pests and plant diseases, Best Agricultural Practices, Watershed, Mandi details etc. It also developed and made functional SMS/mKisan Portal (www.mkisan.gov.in) for sending advisories on various crop related matters to the registered farmers through SMSs. Various other mobile applications have also been developed to facilitate dissemination of information to farmers on critical parameters such as Weather, Market Prices, Plant Protection, Agro-advisory, Extreme Weather Alerts, Input Dealers (of Seed, Pesticide, Fertilizer, Farm Machinery), Soil Health Card, Cold Storage & Godowns, Soil Testing Laboratories and Crop Insurance Premium Calculator (Indian Government – Department of Agriculture and Farmers Welfare, 2022a).

6.3.2. India Digital Ecosystem of Agriculture (IDEA)

The Department of Agriculture, Cooperation, and Farmers Welfare is laying down a framework to build AgriStack, called the 'India Digital Ecosystem of Agriculture (IDEA)'. AgriStack seeks to build a National Digital Agriculture Ecosystem to enhance agriculture's efficiency and productivity and improve farmers' welfare and income outcomes. This Ecosystem shall help the Government in effective planning towards increasing the income of farmers in particular and improving the efficiency of the agriculture sector as a whole scheme (Indian Government – Department of Agriculture and Farmers Welfare, 2022b).

6.3.3. National Agriculture Market (eNAM)

Launched in April 2016, the eNAM is a pan-India electronic trading portal that links the existing Agricultural Produce Market Committee (APMC) mandis to create a unified national market for agricultural commodities. eNAM helps farmers sell products without the interference of any brokers or mediators, by generating competitive returns from their investment (India Brand Equity Foundation, 2021)

6.3.4. Sub Mission on Agricultural Mechanization (SMAM)

Launched in 2014, SMAM aims at 'reaching the unreached' by bringing to the small and marginal farmers the benefits of farm mechanization by Promoting 'Custom Hiring Centers', creating hubs for high-tech and high-value farm equipment, distribution of various agricultural equipment, creating awareness among stakeholders through demonstration and capacity building activities, and ensuring performance-testing and certification at designated testing centers located all over the country (Indian Government – Department of Agriculture and Farmers Welfare, 2022b)

6.3.5. Direct Benefit Transfer (DBT) Central Agri Portal

Launched in January 2013, the DBT Agri Portal is a unified central portal for agricultural schemes across the country. The portal helps farmers adopt modern farm machineries through government subsidies (India Brand Equity Foundation, 2021)

7. CANADA

“Canada is the fifth-largest exporter of agri-food in the world behind the EU-27 block of countries, U.S., Brazil, and China, and exported to nearly 200 countries in 2022” (AAFC, 2023b). Canada is also one of the few countries with the capacity to expand its exports to a hungry world (Calgary Economic Development, n.d.). However, the farm composition in Canada is changing dramatically; “the average farm size almost doubled over the last 50 years due to consolidation and technological advances” (AAFC, 2023b). With so much of the Canadian economy and global food supply dependant on Canadian agriculture, it’s critical for the Canadian and Provincial governments to enact forward-thinking and ongoing policies and programming that enables sector success and growth.

7.1. THE SUSTAINABLE CANADIAN AGRICULTURAL PARTNERSHIP (SCAP)

The Canadian Agricultural Partnership (CAP) was \$3 billion, five-year (2018-2023) investment by federal, provincial and territorial governments that ended in 2023. Its purpose was to strengthen and grow Canada's agriculture and agri-food sector (Agriculture and Agri-Food Canada [AAFC], 2022). Objectives included (AgCanada, 2022):

- Reduce the sector’s greenhouse gas emissions by 3-5 million tonnes
- Achieve \$250 billion in agriculture sector revenues and \$95 billion in sector export revenues by 2028

It’s too soon to truly understand the outcomes and financial impact of these investments. However, it must have demonstrated sufficient promise as the three levels of government renewed this commitment in 2023 with another \$3.5 billion from 2023-2028, renaming it as the **Sustainable Canadian Agricultural Partnership (SCAP)** (AAFC, 2023a).

The five key priority areas are (AAFC, 2021b):

- Building sector capacity, growth and competitiveness
- Climate change and environment
- Science, research and innovation



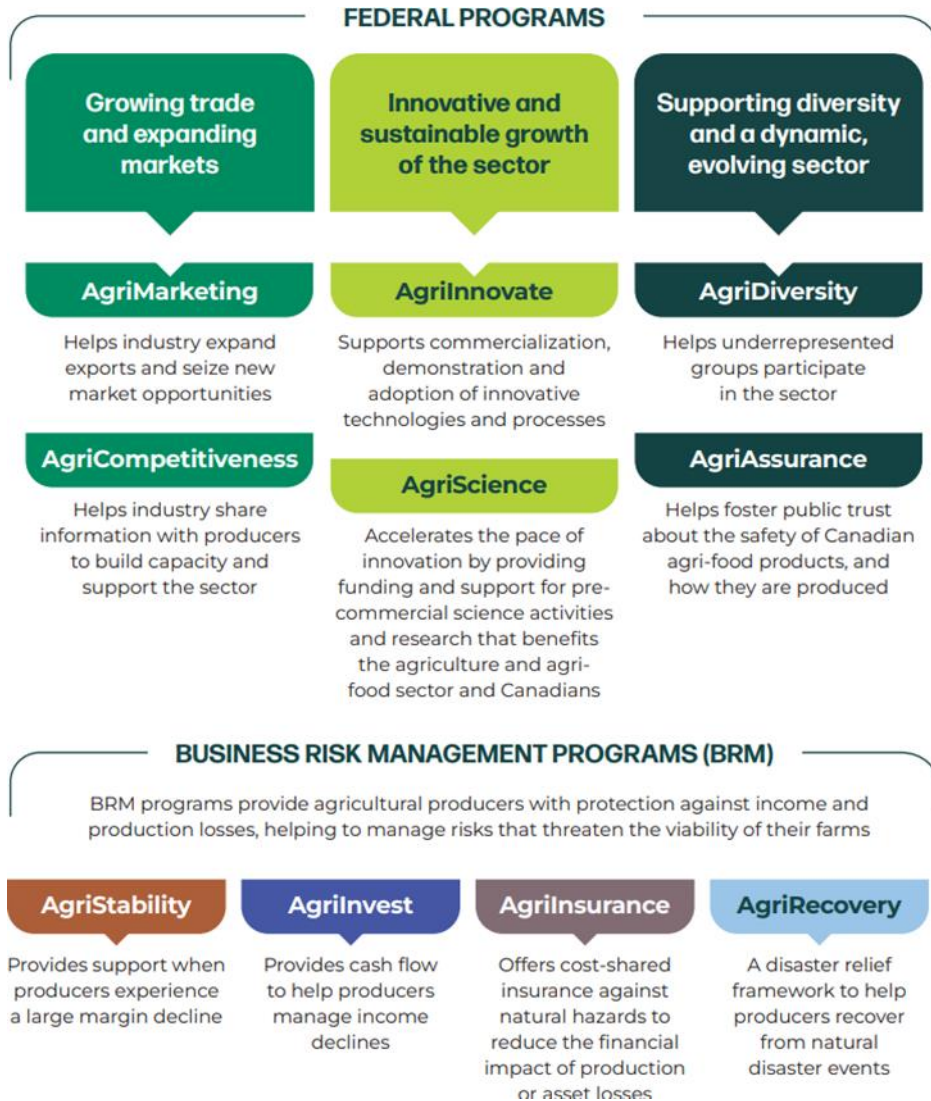
Canadian producers also have access to an enhanced suite of business risk management (BRM) programs to help them manage significant risks that threaten the viability of their farms and are beyond their capacity to manage.



(AAFC, 2023a)

- Market development and trade
- Resiliency and public trust

The programs organized by SCAP are summarised in Figure 3 (AAFC, n.d.).



Source: AAFC, Government of Canada

Figure 3: Government programs supported by SCAP

7.1.1. The Guelph Statement

A joint initiative by Canada's federal, provincial and territorial Ministers of Agriculture, the Guelph Statement was released on November 11, 2021. It guides the direction of SCAP and sets the direction for the next agricultural framework, with a shared vision for Canada to be recognized as a world leader in sustainable agriculture and agri-food production and to position Canada's agri-food producers, processors, and others in the sector for continued success. It outlines several priorities, including making targeted investments in science, research and innovation, supporting sustainable agriculture and economic growth, building sector capacity and growth, and enhancing resiliency (AAFC, 2021b).

7.2. FEDERAL SUSTAINABLE DEVELOPMENT STRATEGY (FSDS)

The 2022-2026 FSDS is Canada's fifth FSDS and the first to:

- be developed under a strengthened Federal Sustainable Development Act, which requires the government to develop and report on a federal sustainable development strategy including goals, targets, actions, short-term milestones and implementation strategies from across the Government of Canada together in one place.
- be oriented toward the 17 Sustainable Development Goals (SDGs) of the United Nations 2030 Agenda for Sustainable Development
- provide a balanced view of the environmental, social and economic dimensions of sustainable development (Government of Canada, 2022)

The Act is a legal framework for developing and implementing the FSDS, which makes decision-making related to sustainable development more transparent and subject to accountability to Parliament with a view to improving the quality of life of Canadians (Government of Canada, 2008).

7.2.1. FSDS Goal 2: Support a healthier and more sustainable food system

While agriculture plays small roles in other goals within the FSDS, Goal 2 is where the Department of Agriculture and Agri-Food will play a leading role. This goal's focus on a healthier and more sustainable Canadian food system directly supports SDG Global Indicator Framework targets. Two aspects of the goal are particularly relevant to this report (Government of Canada, 2022):

- 2.3: By 2030, double the agricultural productivity and incomes of small-scale food producers through secure and equal access to land, inputs, knowledge and financial services
- 2.4: By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, help maintain ecosystems, strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and progressively improve land and soil quality.

These are important because a planful, government-facilitated approach to digitization will be required in order to achieve these goals, compete internationally and reverse the curve.

7.2.2. Additional agriculture-related programs within FSDS

Investments through programs such as the **Agricultural Climate Solutions program** and the **Agricultural Clean Technology program** are targeting increased support to farmers to develop and adopt nature-based agricultural management practices to reduce emissions, store carbon in healthy soil and enhance resiliency; adoption of clean tech on farms, including for renewable energy, precision agriculture and energy efficiency; and working with farmers and stakeholders to reduce methane and fertilizer emissions in the agricultural sector.

Agriculture and Agri-Food Canada will also be creating a **No-Waste Food Fund** to help all players along the food supply chain to commercialize and adopt ways to eliminate, reduce or repurpose food waste (Government of Canada, 2022).

7.3. SUSTAINABLE AGRICULTURE STRATEGY (SAS)

In December 2022, AAFC announced the launch of consultations to develop SAS to help set a long-term direction to improve environmental performance in the sector, support farmers' livelihoods and strengthen the business vitality of the Canadian agricultural industry (AAFC, 2023c).

AAFC released a summary of what was heard during the SAS consultations. Sections 3.2, 3.3 and 3.4 of "What we Heard Report: SAS" reflect on the contours of the upcoming strategy vis-a-vis the digitalization of agriculture. While the summary is long, digital-related highlights include (AAFC, 2023d):

- Abundance of support around the goals regarding data and measurement
- Infrastructure, including broadband connectivity, was identified as a key barrier for the adoption of technologies, especially precision and digital technologies on-farm

On March 31, 2023, AAFC concluded the online engagement period of the Strategy consultation process. AAFC will continue to engage with the SAS Advisory Committee, and other stakeholders, to build the Strategy (AAFC, 2023c).

7.4. INDIRECT SUPPORT POLICIES AND PLANS

7.4.1. Canada's Innovation and Skills Plan

In 2017, Canada introduced its agenda to build Canada as a world-leading innovation economy, including in agri-food, clean technology and digital industries. Specifically for digital, the "Skills" part of the plan included Teaching Kids Digital Skills and Coding. The plan invested \$950 million over five years, starting in 2017–18, in support of a small number of business-led innovation superclusters. It also provided access to up to \$400 million through the Business Development Bank of Canada on a cash basis over three years, beginning in 2017–18, for a new Venture Capital Catalyst Initiative that will increase late-stage venture capital available to Canadian entrepreneurs (Government of Canada, 2017).

7.4.2. Food Policy for Canada

Developed by AAFC, it's a roadmap for a healthier and more sustainable food system in Canada. The policy was developed in 2017 with feedback from those who work in the food system and those who are active on food issues such as food security and food waste. The policy guides food-related decisions and actions across government and society to support a healthy and sustainable food system in Canada. It was launched with over \$134 million in initial investments and input from the Canadian Food Policy Advisory Council (Government of Canada, 2020).

7.5. PARTNERSHIPS AND TRADE AGREEMENTS

7.5.1. USMCA

In December 2019, the Mexican Senate approved the United States-Mexico-Canada Agreement (USMCA), to replace NAFTA from 1994. The Agreement was approved by the US Senate in January 2020 and by the Canadian Senate in March 2020. Among other things, the new trade agreement intends to boost agricultural biotechnology and gene editing trading by promoting co-operation, information sharing and other trade rules in those areas (OECD Library, 2020).

7.5.2. EU-Canada Partnership

In line with the EU's "Farm-to-Fork" strategy and Canadian agricultural priorities, the EU-Canada Dialogue on agricultural sustainability was launched at the June 2021 EU-Canada Summit, within the framework of the Agriculture Dialogue under Canada-Europe Trade Agreement (CETA). EU-Canada dialogue on sustainability, environmental stewardship and climate action in agriculture occurred between June 2021 and March 2023. The dialogue has taken the form of five workshops on soil health, reduction of greenhouse gas emissions in the livestock sector, organic production, the sustainable use of fertilisers, and pesticide use in agricultural production, respectively (Government of Canada, 2023).

In comparison to regions like the EU and Australia, Canada appears to lag in terms of government support and leadership in the digitization of agriculture; reversing the curve is less of a priority for Canada.

8. UNITED STATES (US)

Digital agriculture is recognized as an important part of the solution to several challenges facing U.S. agriculture, including rising production costs and labour shortages. Precision agriculture is a chief solution. The adoption of yield maps and soil maps and variable rate technologies (VRT) has been substantial on corn and soybean acreage for years; however, adoption is only between 5-25% of total U.S. planted acreage for winter wheat, cotton, sorghum

and rice. Adoption of automated guidance has increased sharply in the past 20 years, with application on well over 50% of the acreage planted to corn, cotton, rice, sorghum, soybeans and winter wheat (McFadden, M., Njuki, E. & Griffin, T., 2023).



As a global agricultural leader, the US recognizes that:

The global economy is increasingly intertwined with digital technologies, with one estimate predicting that the digital economy will be roughly a quarter of the entire global GDP by 2025. While that growth is not evenly distributed, and digital investments may lag in the agriculture sector in some target countries, failure to capitalize on the potential that digitization of food systems brings will lead to an increase in global disparity. This is more pressing in the face of emerging technologies, which will potentially transform parts of the food system through dramatic efficiency gains, unparalleled predictive capacity, and reduced waste.



(United States Agency of International Development [USAID], 2021)

Despite this success internally, the US relies on the success of global agriculture to feed its population as well. The US seems to focus a significant amount of its attention to digitizing agriculture globally.

8.1. NITED STATES GOVERNMENT GLOBAL FOOD SECURITY STRATEGY (USG GFSS)

The USG GFSS presents an integrated whole-of-government strategy and agency-specific implementation plan as required by the Global Food Security Act of 2016. It aims to end global hunger, poverty and malnutrition through the Feed the Future initiative. The strategy is currently in its second iteration.

8.1.1. USG GFSS 2017-2021

One of the goals of the first iteration of the USG GFSS was “Strengthened inclusive agriculture systems that are productive and profitable”. To accomplish this, the plan invested in digital technologies for real time data collection, analysis and exchange that improve agricultural practices and yields, enable nimble market adjustments and signal new food and agriculture system opportunities. Another goal was to engage youth in agriculture, in part, through applying technology to engage youth, with an emphasis on digital technologies such as mobile money, mobile devices and the internet. Through private sector partnerships, the strategy set out to harness the growing uptake of digital (including mobile) technologies and internet-based business models and entrepreneurship.

The strategy also talks about the uptake of sensing technologies, geospatial data, big-data analysis of production and weather and telemetric farming can make agriculture more precise, productive, resilient, profitable and financially inclusive (USAID, 2016b).

8.1.2. USG GFSS 2022-2026

Due to the success of the first iteration of the USG GFSS, the second iteration launched in the fall of 2021. The USG GFSS 2022-2026 builds on the previous five-year strategy and notes that “digital technology must play an integral role in the USG’s work in food systems, rather than being treated as an add-on or an afterthought. This will require an ecosystem approach that considers the benefits, drivers, barriers and risks of digital technology for all stakeholders in food systems, while prioritizing financial viability of digital products and services.”

This strategy recognizes the many advantages and limitations of integrating digital technology into the global agriculture ecosystem.

We will continue to support...new and improved technologies in agriculture and food systems to improve food security and nutrition, while also taking steps to mitigate technological divides. Continued support to data-driven, intensive, hyper-local agriculture requires an integrated set of digital approaches to be successful, such as linking artificial intelligence systems, big-data crop models, targeted weather forecasting, and specific variability in soils to provide localized information on production inputs and practices. Those insights must also be complemented by financially viable and producer-centric ICT-enabled extension services, as well as innovations in improved seed availability, distribution, logistics and storage to turn these analytics into good practice on farms and in market systems (USAID, 2021).

However, the strategy doesn’t go as far as providing specific funding or describing how the US and the world need to evolve and adapt when it comes to digitizing agriculture.

There are several Activity Design Guidance documents for implementing the U.S. Government’s GFSS. One entitled “Digital Technology” outlines constraints that might have implications on program design and solutions that can be undertaken from a digital agricultural perspective. For example, the USAID Mobile Access Diagnostic Tool provides an online platform for measuring the strength of a mobile ecosystem at national and regional levels. In addition, a number of USAID Missions have undertaken digital agriculture ecosystem assessments to better understand the opportunities and barriers to effectively and equitably using digital technology in their food security programs (USAID, 2023).

8.1.3. Digital Development for Feed the Future (D2FTF)

Launched in September 2015 under the USG GFSS, this three-year partnership was a collaboration between the U.S. Global Development Lab and the Bureau for Food Security at USAID and was aimed at integrating digital tools and approaches into the Feed the Future portfolio (USAID, n.d.b).

D2FTF is focused on four categories of digital tools, based on evidence on their impact: precision agriculture (including sensor technology), digital financial services, data-driven agriculture and ICT-enabled extension. D2FTF is scaling the use of these tools through different methods of engagement: technical assistance to Feed the Future programs, capacity building for Feed the Future teams, and through strengthening the knowledge base on best practices (USAID, 2016a). Read about D2FTF case studies by following the source link (USAID, n.d.c).

8.2. THE DIGITAL STRATEGY (2020-2024)

A separate but also important initiative is the USAID Digital Strategy (2020-2024), which will position the Agency to advance their mission—to end the need for foreign assistance—through digitally supported programming that fosters the Journey to Self-Reliance in partner countries.

The Digital Strategy centres around two objectives:

- Improve measurable development and humanitarian assistance outcomes through the responsible use of digital technology in USAID’s programming
- Strengthen the openness, inclusiveness and security of country-level digital ecosystems

These objectives support the goals and principles outlined in key policy documents, including the USAID Policy Framework, the Department of State-USAID Joint Strategic Plan and the U.S. National Cyber, National Security, and Counterterrorism Strategies. While it is conceivable that the Digital Strategy will be important to the US’s success in the pursuit of reversing the curve using digital agriculture, it’s not clear specifically how this strategy will play a role.

8.2.1. Digital Strategy Action Plan (DSAP)

The Bureau for Resilience and Food Security’s (BRFS) DSAP follows the launch of USAID’s Digital Strategy 2020-2024. BRFS’s priorities align with the broader objectives of The Digital Strategy (Bureau for Resilience and Food Security, 2022).

8.2.2. Digital Ecosystem Framework

USAID’s Digital Ecosystem Framework offers a practical structure that defines the core and cross-cutting elements of a country’s digital ecosystem. This Framework provides a way to understand a country’s digital operating environment and inform the design of effective, sustainable projects and activities (USAID, 2022).

8.3. OPEN, PUBLIC, ELECTRONIC, AND NECESSARY (OPEN) GOVERNMENT DATA ACT

Another important and separate policy is the OPEN Government Data Act. Data drives effective management of US programs, with real-time feedback loops and geospatial analysis informing targeted efforts and OPEN is a law that seeks to change how government information is formatted, catalogued and presented for public access and use. It mandates federal agencies, including the US Department of Agriculture, to publish data online in machine-readable formats, shaping global data system strengthening efforts. It calls for government information to be made “open by default” and requires agencies to conduct comprehensive data inventories (USAID, 2021). This act will impact the digitization of agriculture in the US, even if how it will be affected isn’t clear yet.

9. MEXICO

The Secretariat of Agriculture and Rural Development⁸ was renamed as such in 2018 (from the previous Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food) when Andrés Manuel López Obrador was inaugurated as President. Between 2020-2022 (OECD Library, 2023):

- Mexico’s producer support estimate (PSE) was 11.3% of gross farm receipts, much lower than in 1991-1993 (31%) (PSE for all jurisdictions in this report can be found in Appendix C)
- Budgetary transfers were predominately for electricity and the fertilizer programme (not digital technology)
- However, 55% of the general services expenditures, GSSE line item, was directed toward agricultural innovation, extension and training (even though the proportion of the GSSE account is lower than the OECD average)

In 2022-2023, there was not any new policy in the digital realm (OECD Library, 2023).

9.1. NATIONAL DEVELOPMENT PLAN (NDP)

Under the 2013–2018 National Plan, eleven federal programs were established to improve the productivity and competitiveness of Mexico’s agri-food sector. Only one of those programs is relevant to this report, which is the Agri-food Productivity and Competitiveness Program (AFPCP).

9.1.1. *Agri-food Productivity and Competitiveness Program*

The overall objective of the AFPCP is to boost productivity in the agri-food sector through investing in physical infrastructure, human capital and technology to ensure food security. Mexico’s agricultural subsidy expenditure under the AFPCP in 2018 was 11.9 billion pesos (US\$618 million), almost four times higher compared to 3.2 billion pesos (US\$240 million) in 2014. Only two sub-programs of the AFPCP specifically talk about leveraging technology to advance agriculture, but it’s not in the common Agriculture 4.0 ways happening in other regions discussed in this report (Wu, Soto-Caro, & Guan, 2022):

⁸ The Spanish name and acronym are “Secretaría de Agricultura y Desarrollo Rural” (SADER).

Sub-program 1 of AFPCP: National System of Agroparks

One use of that investment was to develop and promote a National System of Agroparks. An agropark is a high-tech greenhouse cluster that provides space for companies to grow specialized products for export using state-of-the-art technology. However, the type of technology is unclear. The most relevant detail provided about the incentives was for:

Equipment of agribusinesses installed in agroparks

Up to 50% of total investment, not exceeding 100,000,000 pesos per agropark
Up to \$10,000,000 pesos per agribusiness installed within agropark

Sub-program 2 of AFPCP: South-Southeast Productive Development

This subprogram contains two components—finance incentives and strengthening productivity in the South-Southeast of Mexico in agriculture, fishing and aquaculture. The component of strengthening productivity intends to encourage technology development, training, and product certification.

Technological development⁹

For Applicants A: 30–50% of total project cost
For Applicants B: p to 90% of total project cost

The next iteration of the National Development Plan is for 2019-2024, which aims to specify the national objectives, strategy and priorities for Mexico’s comprehensive, equitable, inclusive and sustainable development. The direction from the NDP for agricultural initiatives is vague. The NDP indicates several programs focused on achieving food self-sufficiency and rescuing Mexico’s agricultural activity (i.e., farming); however, unlike its predecessor, this plan doesn’t include anything about digital technology.

9.1.2. Sectoral Programme for Agriculture and Rural Development (SPARD) 2019-2024

The Mexican government replaced the previous Sectoral Development Programme for Agriculture, Fisheries and Food 2013-2018 with the Sectoral Programme for Agriculture and Rural Development 2019-2024, which also appears to be called the “Agriculture and Rural Development Sector Program 2020-2024” as these two names are used interchangeably. Both, being the same program, are said to guide the relevant agricultural implementation of the National Development Plan (NDP) during those years.

The objectives of the SPARD 2019-2024 are (OECD Library, 2022):

- Improve agricultural productivity for food self-sufficiency
- Bring down poverty rates in rural areas

⁹ Applicants A are individuals with a monthly income level above the decile of IX, as defined by INEGI (National Institution of Statistics of Mexico), while Applicants B are individuals with a monthly income level within deciles of I to IX.

- Increase small-scale agricultural producers' incomes

However, the programme, under either name, also doesn't talk about digital solutions.

10. UKRAINE

Agriculture is one of the main sectors of the Ukrainian economy. The country's arable land area is equivalent to almost 30% of arable land in the EU and accounts for about 25% of the world's most fertile black soil. Agricultural and food product exports rose from 20-40% between 2012 and 2018. The Ukrainian agricultural sector is dominated by large farms and agroholdings, with about 70 agricultural companies engaged in relative monoculture on 25% of the arable land. Besides the large entities, an estimated 900,000 or so unregistered smaller or family farms produce crops. Because of the very favourable conditions (climate and rich soils), Ukraine's agricultural sector has great potential for improvement and further development (International Telecommunication Union [ITU], 2020).

Due to the war with Russia, virtually all traditional support programmes were suspended at the beginning of 2022, while new temporary measures were introduced as wartime measures. As such, the new measures do not include the advancement of digital agriculture because the main focus is not the long-term advancement of the industry; the focus is producing enough food for the country, including the military (OECD Library, 2023).

However, prior to the war there was no regulation or individual policies, programs or directions in the context of precision agriculture. There are common regulations applied to the types of equipment (hardware) when put into circulation in Ukraine (production and release on the market of own equipment or imports). In most cases, hardware used in precision farming is defined by Ukrainian law as radio frequency / radio equipment or electromagnetic equipment. These are the same GPS trackers, sensors, etc. in addition, there is a separate regulation when using a UAV. These regulations can be found at this source (Kingdom of the Netherlands, 2021).

10.1. STATE IN A SMARTPHONE

The Ministry of Digital Transformation was formed in 2019 and launched the "State in a Smartphone" project, or the Diia App (also referred to as Diya). The project is expected to digitize agriculture by providing farmers with easy access to public services, helping them learn how to use digital technologies, supporting the development of agricultural businesses, and facilitating the collection and analysis of agricultural data. Through the app, farmers can (GLOBSEC, 2023):

- Digitally access legal documents such as identity cards and passports, which is useful when applying for agricultural subsidies or loans
 - Access a variety of services, such as applying for permits or reporting harvest data
 - Learn how to use digital technologies, thereby increasing their ability to benefit from digital agriculture (within the app is "Diia.Digital" aimed at eliminating digital illiteracy)
 - Start or grow their own agricultural businesses through "Diia.Business" aimed at developing small and medium businesses
 - Make informed decisions about their farming practices, leading to increased productivity and sustainability, as a result of the agricultural data collection and analysis capabilities
-

10.2. CSIS UKRAINE ECONOMIC RECONSTRUCTION COMMISSION

In response to the war, CSIS and the Ukraine formed the bipartisan and international CSIS Ukraine Economic Reconstruction Commission in July 2022 to produce a policy framework that will help attract private sector investments to support Ukraine's future economic reconstruction. The Commission's agriculture sector working group, comprising of government officials, private sector representatives, academics and civil society members from the United States and Ukraine, put forth recommendations. However, the only recommendation related to technology has to do with dealing with a limited supply of fertilizer, and therefore, employing soil testing, and satellite and artificial intelligence technologies to reveal farms' deficit of nutrients, saving costs by eliminating potential overapplication of nutrients (Center for Strategic and International Studies, 2022).

11. ALBERTA

Alberta is a leading farming province (St. Pierre & McComb, 2022) and really feels like it is trying to do its part to reverse the curve:

- The highest farm operating revenues in Canada
- The second largest total farm area in Canada
- More than a quarter of Canada's field crop area
- More beef cows than any other province
- Is among the national leaders in use of auto-steer and drone technology
- The second highest rate of succession planning in Canada
- The second highest percentage of female farm operators
- The proportion of farm operators working off the farm is increasing

A 2019 study from Calgary Economic Development revealed that the agribusiness sector is the fastest-growing adopter of digital transformative technologies in Alberta, with forecast spending increasing by 23% from 2019 to 2022 (Calgary Economic Development, n.d).

11.1. SUSTAINABLE CANADIAN AGRICULTURAL PARTNERSHIP (SCAP) IN ALBERTA

SCAP is the Canadian program discussed above. Alberta's SCAP funding is \$508 million between 2023-2028 to support the needs of Alberta's agriculture and agri-food sectors. Alberta's programs will aim to spur growth in the agriculture sector by supporting value-added processing competitiveness, attracting new investment and investing in producer-led agriculture research, among other goals (AAFC, 2023a).

11.1.1. *Emerging Opportunities Grant Program*

Supports projects that focus on innovation and result in significant company growth and sector impact. Projects can include new technologies, best new practises, significant capacity expansions and new builds. Funding (Alberta Government, n.d.a):

- Maximum grant funding provided by this program is \$1,000,000 per fiscal year, to a project maximum of \$2,000,000.
 - Projects conducted by agriculture and bio-industrial processors must have a minimum total project investment of \$2 million.
-

- Costs are shared at 25% for approved capital expenses and 50% for approved non-capital expenses.
- Eligible projects must include one or a combination of the following activities:
- Equipment and engineering related to new processing facilities and significant expansion projects that increase processing capacity in Alberta
- Initiatives that explore market opportunities and directly address barriers to export and new market access
- Activities that promote collaboration amongst companies to grow the sector
- Any other activity deemed eligible by the Minister that supports an emerging opportunity in the sector

11.1.2. Farm Technology Program

With two streams, the Farm Technology Stream supports adoption of innovative technology that minimizes agricultural waste and optimizes farm efficiency. It provides financial incentives on new technologies that are commercially available and already demonstrated under Alberta conditions. To be eligible for funding, the program targets technology that is proven but not yet widely adopted within an applicant's farm type. Eligible expenses will be cost-shared at 50% grant and 50% applicant (Alberta Government, n.d.b).

11.1.3. Results-Driver Agriculture Research (RDAR)

The Government of Alberta conducted numerous in-person and online sessions, engaging with over 2,000 farmers, ranchers, and industry partners to glean their insights on the future of agricultural research in Alberta. RDAR was created in 2019 as a result of these consultations. RDAR's vision is that Alberta's agriculture sector is achieving its full potential through the acceleration and adoption of results-driven research (RDAR, n.d.b).

11.1.4. Accelerating Agricultural Innovations (AAI) 2.0

For researchers who are interested in conducting research related to new innovations, advancing existing innovations, or exploring new beneficial management practices. Funded using SCAP funds, RDAR is delivering AAI 2.0 under a Program Administrator Agreement with the Alberta Ministry of Agriculture and Irrigation (AGI). AAI 2.0 will (RDAR, n.d.a):

- Research projects that demonstrate the feasibility and potential for application of new innovations (products, technologies, processes and practices) by determining if the innovation is appropriate for use in Alberta by the end-user and how easily it can be adopted
- Advance the adaptation of existing innovative technologies, products, practices, and processing for Alberta-specific conditions.

11.2. THE ALBERTA DIGITALIZATION AGRICULTURE PROGRAM

The program will identify the challenges and opportunities for the digitalization of Canada's agriculture. With funding from the Alberta Government, the program's goals include fostering data management best practices, developing policy recommendations and enhancing transparency in the agri-food space. Desired outcomes of the program include policy recommendations to: (Simpson Centre, n.d.)

- Raise awareness and create buy-in for available AgTech and its benefits in improving productivity, as well as land and animal stewardship.
 - Promote the value of adopting digital technologies for data collection and regional risk management
 - Build capacity for data literacy and data use, enabling data-driven decision-making in the agricultural sector
-

- Assess infrastructure requirements for digitalization (e.g., bandwidth in rural Alberta)
- Prioritize policy effectiveness (e.g., farm equipment subsidies)

11.3. ECONOMIC DEVELOPMENT IN RURAL ALBERTA PLAN (EDRAP)

EDRAP is a series of key strategies and measurable actions to ensure rural Albertans have economic opportunities where they live (listed in table below) (Alberta Government, n.d.c). It sets out a 5-year commitment that is intended to support rural Albertans’ economic developments efforts that are innovative, contribute to diversification and promote sustainable, long-term growth. that guides rural economic growth, reflecting on innovation, diversification and sustainable, long-term economic development (Alberta Government, n.d.d).

| | |
|---|--|
| Small Community Opportunity Program | Provides grants between \$20,000 and \$100,000 for Indigenous and small communities, and the non-profits they work with, to build capacity in agriculture, local economic development and small business supports. The program will provide up to \$3 million per year in 2023-24 and 2024-25. |
| Irrigation Infrastructure Investment | Expands and modernizes Alberta’s irrigation infrastructure through an investment in irrigation infrastructure of almost \$933 million in partnership with 10 irrigation districts. |
| Alberta Broadband Strategy | Makes reliable, affordable, high-speed internet a reality in rural, remote and Indigenous communities through a \$390 million investment over the next 4 years. |
| THRIVE Canada Accelerator | Supports early-stage startups whose technologies help drive towards a more efficient, sustainable and secure agriculture future. |
| Alberta Agri-Food Investment and Growth Strategy | Set targets to attract \$1.4 billion in investment by 2024 and create 2,000 jobs in the agri-food sector. Investing in value-added agricultural processing capacity to secure increased investment that will help expand the agri-food industry by supporting value-added processors to establish and expand their operations. |
| Alberta Agri-processing Investment Tax Credit | Creates the right conditions to attract large-scale investments to grow the value-added agricultural industry and diversify the economy. ¹⁰ |

¹⁰ [Alberta Agri-processing Investment Tax Credit | Alberta.ca](https://www.alberta.ca/alberta-agri-processing-investment-tax-credit.aspx)

11.4. ALBERTA INNOVATES

A public agency that reports to the Minister of Jobs, Economy and Innovation, Alberta Innovates provides funding, business advice and connections, applied research and industrial testing facilities to accelerate research and innovations that benefit Albertans, and will be fundamental in Alberta reversing the curve.

*“Today, we are looking beyond the horizon to drive innovations that will prepare Alberta for a digital, net-zero future.”
~ Alberta Innovates*

11.4.1. Agri-Food and Bioindustrial Program (ABIP)

Offers funding to accelerate the development of technologies to enhance Alberta’s

agri-food and bioindustrial sectors. Qualifying projects must support technology that could optimize productivity, reduce production costs, add value to a commodity or reduce harmful environmental effects. Funding of up to \$500,000 per project is available, up to 75% of total project costs. The measurable effects of the program are (Alberta Innovates, n.d.a):

- The development and advancement of innovations that will lead to strong agri-food and bioindustrial sectors and a value-added resource industry in Alberta, helping the province become a global leader in environmental, social and governance performance
- Improved economic prosperity and social well-being in Alberta
- Mitigation of negative environmental impacts

11.4.2. Alberta Scaleup and Growth Accelerator Program (ASGAP)

Alberta has a scaleup gap. While half of all startups survive over five years, only 0.1% of small firms become mid-sized, and only 2% of mid-sized firms become large. In partnership with three levels of government (the Government of Alberta, Prairies Economic Development Canada, and both the City of Edmonton and C

ity of Calgary), Alberta Innovates designed and continues to administer a provincial scale-up and growth strategy that has since developed into a burgeoning program that leverages the idea of global accelerators. The program provides end-to-end services for companies who are just fleshing out their business plans all the way to organizations who need advice or investment to help them through the hurdles of going global. In 2021, Alberta Innovates contracted with one local pre-accelerator and four global accelerators to bridge the scaleup gap¹¹ to support agricultural startups (Alberta Innovates, n.d.c).

Accelerators are “programs that give developing companies access to mentorship, investors and other support that help them become stable, self-sufficient businesses.” ~ BDC

11.4.3. Smart Agriculture and Food Digitalization and Automation Challenge (SAFDAC)

An initiative launched by Alberta Innovates in 2020 and is now closed, the SAFDAC supported projects that planned to result in smart technology development or knowledge generation that can potentially increase productivity, reduce cost of production or increase the value of Alberta agri-food commodities. Projects had to provide solutions to challenges

¹¹ Alberta Catalyzer Pre–Accelerator, Alberta Accelerator by 500, Plug and Play Alberta Accelerator, TELUS Community Safety and Wellness Accelerator powered by Alchemist, and SVG Thrive Studio, Pre-Accelerator and Accelerator.

faced by the agri-food sector and clearly demonstrate the social, economic and environmental benefits to Alberta's agri-food industry. Smart technologies for this program included:

- Development of new applications for digitalization of the agri-food sector utilizing tools such as AI & ML to develop data-driven decision models
- Prototype development and validation of new technologies, such as the use of remote monitoring and imaging data
- Research into autonomous systems and prototype development that reduce cost or improve quality and safety of agriculture and food products
- Validation of new smart technologies and solutions to increase farm productivity and supply chain functionality and mitigate the impact of biotic and abiotic stress.

Funding available for the program was up to \$2,000,000 CAD total for eligible projects. Funding for individual projects was a maximum of \$500,000 CAD (Alberta Innovates, n.d.b). Learn about some of the projects funded under this program [here](#).

12. RISK: CYBERATTACKS

Digital agriculture must be at the forefront of discussions about protecting critical infrastructure because cyberattacks against it are on the rise. One estimate of the expected growth of the smart agriculture market is that it will more than triple from \$10 billion in 2020 to over \$30 billion by 2028. As such, the consequences of an attack are only increasing. The absence of digital agriculture from discussions about critical infrastructure protection is a major oversight.

In the United States, digital agriculture was mentioned by the Federal Bureau of Investigation (FBI) in a bulletin in April 2022. The FBI mentions a series of cyberattacks against farms, but only provides short, broad recommendations to farmers. Meanwhile, the Cybersecurity and Infrastructure Security Agency (CISA), the agency responsible for securing critical infrastructure, has not updated its food and agriculture sector specific plan since 2015, and there is no mention of digital agriculture technologies in its new 2023-2025 strategic plan.

Digital agriculture technologies are also notably absent from EU statements and regulations. The protection of critical infrastructure in the EU is regulated by the Network and Information Systems Directive (NIS) which will soon be superseded by a new directive, NIS 2.0. Neither version refers to digital agriculture explicitly. NIS 2.0 briefly recognizes the growing threat of cyberattacks in agriculture; however, after acknowledging the threat, the document says nothing further on the issue.

Government officials need to integrate digital agriculture into critical infrastructure protection and issue useful guidance and tools to help farmers secure their growing stocks of digital equipment. A good example is a program introduced in 2021 in Canada designed to assess the cybersecurity practices of the digital agriculture sector (Kouloufakos, T., 2022). The Cyber Security Cooperation Program was launched in August 2019 under the National Cyber Security Strategy. It has \$10.3 million in available funding over 5 years with \$4.2 million available from 2021-2024 (Government of Canada, 2021).

13. CONCLUSIONS AND RECOMMENDATIONS

Having reviewed government policies on digital agriculture from Alberta, Canada, United States, Europe, China, India, Ukraine, Australia, New Zealand and Mexico, it is evident that Alberta is a relative leader when it comes to investing in

digital agriculture and farmer adoption of digital technologies. Alberta is organized in its planning and policy promotion, with very clear program definitions, measures, eligibility and funding opportunities. However, if Alberta wants to continue to be a leading Canadian province and global jurisdiction in the advancement of agriculture and specifically digital agriculture, there are some areas for improvement.

13.1. JURISDICTIONAL CONCLUSIONS

Of the regions reviewed, the EU and Australia are the leaders with their focus on advancing the agriculture industry leveraging digital technologies, with New Zealand close behind. Mexico and Ukraine government policies have relatively low focus on digital agriculture; of course, the Ukraine has an exception since early 2022 (given the war with Russia).

Table 1 summarizes main conclusions from each jurisdiction evaluated in this report.

| Jurisdictional conclusions | |
|---|---|
| Error! Reference source not found. | The focus the European Commission (EC) and the EU overall are placing on digital agriculture is astonishing; and yet, highly appropriate. The EU is densely populated; they need a lot of food and many countries within don't have a lot of space to produce it. Furthermore, the EU has aggressive environmental goals. Therefore, increasing productivity within the land currently being used (and possibly reversing the curve) is a critical objective while reducing GHG emissions at the same time. The EU has a really strong focus on the farmer when it comes to digital agriculture policy, and that's important. For example, their leading the regions in this report in PSE (see Error! Reference source not found.). They balance out the farmer-focus by also focusing on infrastructure, ecosystems and understanding that for the farmer to have success with digital agriculture, there needs to be a unifying, transparent and comprehensive system where data can flow and be used appropriately. If any jurisdiction is going to reverse the curve first, the EU is a leading candidate. |
| Error! Reference source not found. | The abundance of programs and policies (especially in the realm of data) from the Australian government really demonstrates how dedicated they are to being a leader in digital agriculture, and how important it is for their economy. Although, the level of organization of these programs isn't great – there is a lot of overlap and it can be hard to parse out which programs are supported by which policies, etc.). Like the EU, Australia has a strong focus on the farmer (except for low PSE amounts) while balancing that off well with a focus on strong infrastructure and ecosystems. One might expect Australia to have more of a collaborative approach with other countries, given their reliance on certain export markets (e.g., beef and sheep) and their geographical isolation. However, perhaps this speaks to their current agricultural strength and plan to build on this strength. Consider Australia another leading candidate to reverse the curve first. |
| Error! Reference source not found. | New Zealand, like their closest neighbour Australia, has a strong focus on digital agriculture. However, their focus is less on farmer adoption (and PSE amounts) and more on building up AgTech companies with global AgTech leadership aspirations. This is, in part, why they have a high degree of international collaboration in the digital agriculture space. New Zealand would be the third leading candidate to reverse the curve, in part out of possible necessity, given its small size and it being a small island surrounded by ocean. |
| Error! Reference source not found. | Comparing Alberta to all these other jurisdictions has to be done carefully – comparing a province to entire countries and even groups of countries (EU) is not a fair comparison. However, there is still a lot to take away. Alberta is very organized when it comes to digital agriculture policy. When learning about a program, it's generally quite obvious where the funding is coming from, what the goals or success measures are and what the funding options are. Many other jurisdictions don't provide this level of detail. Alberta's growth potential is large, especially by leveraging their strengths such as beef production. |
| Error! Reference source not found. | Very aware of it's more than 1.3B residents and the amount of food it takes to sustain healthy residents, China has significant focus on enhancing the rural lifestyle overall, and with that, modernizing agricultural capabilities. The combination of large land mass and large number of people |

| Jurisdictional conclusions | |
|------------------------------------|--|
| source not found. | provide a great opportunity for agricultural expansion, and they are already a leading exporter in agricultural products globally. However, they are on their own path with no apparent international collaboration. With this go-it-alone approach, it's no surprise China has a very high focus on the farmer, including high PSE amounts. |
| Error! Reference source not found. | Similar to China, India's agricultural policies are rooted in necessity – with more than one billion mouths to feed, India wants to be as self-sufficient as possible so as to not have to rely on other countries for sustenance. India is taking some smart approaches with strong international collaborations and an above average focus on data within their digital agriculture approach. Their focus on the farmer is strong, which is good – they will need to ensure that the ecosystems their farmers are expected to use are national, streamlined and organized. |
| Error! Reference source not found. | With some of the greatest potential worldwide for increasing agricultural capacity (mainly due to all its land), Canada's policy focus on digital agriculture is very much middle of the road in all aspects. They have some international collaboration but not a lot, they have some focus on the farmer (with average PSE amounts) but most policy focus is on advancing agriculture for the purpose of the industry itself and environmental reasons, and as a result, only have moderate focus on data. It is concerning that Canada could slip behind jurisdictions like New Zealand, Australia and the EU when it comes to AgTech and digital agriculture adoption, potentially making food more expensive to produce in Canada over the long-run. |
| Error! Reference source not found. | The reason the US is lower on the list is because their policies on digital agriculture are largely externally focused, facilitating the growth of agriculture in primarily developing countries. It's unclear how much of this is altruism or self-serving (in that perhaps the US recognizes it needs other nations' food production to be high in order to help feed its roughly 400M residents). Also, an already technologically advanced, capitalist state, the US already has many farmers adopting digital technologies. It's unclear, however, if adoption is happening at a rate sufficient with keeping up with global adoption rates. |
| Error! Reference source not found. | Agricultural policies in Mexico primarily focus on farmer subsidies (for things like electricity and fertilizer) and less so on long-term growth and sustainability. The OECD has many recommendations for Mexico that to-date, they have not shown interest in implementing. Mexico's growth potential would be higher if they focused less on subsidizing current farming methods and more on growing capacity and productivity with existing farms. |
| Error! Reference source not found. | Ukraine has so much natural potential for agriculture growth, or at least they did until the war with Russia began in early 2022, with their abundance of arable land and quality topsoil. The state of that land post-war will only be known after the war is over. Ukraine apparently had some digital agriculture policies in place prior to the war; however, finding evidence of those programs proved futile. Currently, their focus is merely on the survival of their citizens, producing as much food as possible with the infrastructure and farming capabilities they have in place, with little focus on long term growth. There are some international organizations helping Ukraine with agriculture recovery but they are not government policies so are not included in this report. |

Table 1: Conclusions from each jurisdiction

13.2. KEY LEARNINGS AND RECOMMENDATIONS

| # | Key learnings | Recommendations for Alberta |
|---|--|--|
| 1 | Demonstrating to farmers that new technology will increase profitability or direct revenue can help create interest / increase adoption, but it may not be necessary. It could be sufficient to demonstrate that it may provide a similar level of profitability and other benefits important | To ensure policies targeted at increasing farmer adoption of digital technologies are effective, conduct local primary research studies with strategic segmentation to understand the drivers of digital technology adoption by various farmer |

| # | Key learnings | Recommendations for Alberta |
|---|---|---|
| | to that farmer, such as environmental (reduced food waste; less emissions), socioeconomic (highly regarded in local community), behavioural and attitudinal benefits (feeling good about making technologically advanced investments); or it might increase a farmer’s free time. | types (similar to that of a study done in New Zealand not referenced in this report but is available here) and then implement funding / policy to drive adoption in those ways. |
| 2 | Five of every six farms in the world are smaller than two hectares (the size of about three soccer fields) and collectively they produce a third of the world’s food. ¹² | Focus on the small and medium-sized farms when helping farmers adopt digital technology. |
| 3 | Some jurisdictions have hundreds of thousands of farms; it’s not feasible to provide direct subsidies to all of them. However, all the technology in the world won’t matter if there aren’t enough farmers to use it. The farmers and their interests should be at the heart of the strategy. | Rather than target each farm / farmer individually, segment small and medium-sized farmers into manageable groups of like farms / farmers and launch a series of policies targeted at achieving different goals by segment (e.g., farms with older owners will be targeted with programs that incentivize digital adoption with succession planning in mind vs. farms with younger owners will be targeted with funding to help than digitize for the long-term and as leaders in the field). |
| 4 | Jurisdictions are, individually, spending billions internally on developing technology for digital agriculture and various programs. It seems as though countries with similar interests could do a better job collaborating and therefore, make better use of collective funds. | Set itself apart from national jurisdictions by leading global collaboration so knowledge can be shared via online communities of practice, including existing regional networks and global platforms with the ultimate goal of reversing the curve around the world faster and more efficiently, together. Create a database of all the digital technologies on the market and being developed today, which are being employed in which jurisdictions, how effective they are, how they were funded and/or subsidized, and evaluate whether Alberta / Canada should create their own or rely on what’s already available. |

¹² [Agriculture needs technology for resilient food production | World Economic Forum \(weforum.org\)](#)

| # | Key learnings | Recommendations for Alberta |
|---|--|--|
| 5 | Some jurisdictions are more organized than others when it comes to policies encouraging / promoting digital agriculture. For any adoption goal to be reached, it needs to be easy for the user to understand and implement the desired actions. | <p>Continue to be organized and be more organized. Make it clear to stakeholder how each program and policy are connected to each other, make each policy / program with funding setup as similarly as possible, so those heavily involved in leveraging government support can access it more easily.</p> <p>Setup a “program lite” application system for small grants (e.g., under \$50,000) that is shorter and quicker, making easier for applicants to engage with and receive funding.</p> |
| 6 | Many countries are developing or upgrading their agricultural data-collection methods and systems. | <p>Take a leadership role and seek alignment with other provinces and key trading partners:</p> <ol style="list-style-type: none"> 1. Understand Canada’s plan for employing open data systems like that of the EU and offer ways to help that would accelerate the timeline to the benefit of Alberta 2. Work with key Alberta agricultural trading partners to ensure data systems are the same or at least talk to each other to increase efficiency and further establish a competitive advantage over other agricultural trading partners |
| 7 | Some jurisdictions are putting more emphasis on connecting rural communities to high-speed internet, something required for the future of digital technology. It is important for policymakers, industry leaders and technology providers to work together to make desired technology inclusive and accessible for all | <p>Accelerate the pace of installing high-speed internet into rural areas, ideally first targeting those areas with high per capita farming communities, even if this internet is only available via smartphones, allowing farmers access to digital technology they previously couldn’t use.</p> |
| 8 | Cybersecurity is a real threat to digital agriculture. | <p>Invest in a cybersecurity plan for Alberta. Work with the Government of Canada on how Canadian farms and data will be protected.</p> |

13.3. MESSAGE FOR CANADA: DON'T FALL BEHIND

The journal FACETS completed a scoping review of the digital agricultural revolution and ecosystem services and the implications for Canadian policy and research agendas. The review overviews barriers to implementing digital agricultural technologies for better ecosystem services management in the Canadian context. These include economic and political systems, lack of policies on data management, governance and cybersecurity, and limited training and human resources that prevent producers from fully utilizing these technologies. Canadian policies that support digital agricultural innovation should be explicit about the role of specific digital agricultural technologies for a more sustainable agriculture future. This would allow governments to introduce targeted policies (e.g., carbon markets and sector-specific interest rates) and promote targeted investments in education and technology use scenarios that benefit farming (Green, Abdulai, Duncan, Glaros, Campbell, Newell, Quarshie, Bahadur KC, Newman, Nost & Fraser, 2021).

14. APPENDICES

14.1. APPENDIX A: A DISCUSSION ON DEFINING DIGITAL AGRICULTURE.

A consistent definition of digital agriculture does not exist in the literature. Common terms used interchangeably or alongside ‘digital agriculture’ (or ‘digital farming’ or ‘e-agriculture’) include ‘precision agriculture’ (or ‘precision farming’ or ‘precision ag’), ‘smart agriculture’ (or ‘smart farming’) and ‘Agriculture 4.0’ (or ‘Farming 4.0’ or ‘4IR’), referring to digital transformation as the fourth major revolution in agriculture. This can be observed in the literature many times over (for example, the Institute of Electrical and Electronics Engineers [IEEE] (2022), quote on their website “Also called “precision farming”, “smart agriculture”, and “Agriculture 4.0”, smart farming offers farmers several high-tech techniques that can provide valuable data to assist in making decisions.” This inconsistent and interchangeable use of the four terms was also specifically demonstrated by Zhang (2023) who completed a metanalysis of 100 randomly selected studies with one of these terms listed in the key words or used in the titles.

To further convolute the literature, for example, precision agriculture has been defined in 27 different ways over the last 30 years (Research Group in AgrolCT & Precision Agriculture [RGAPA], 2022) before the International Society of Precision Agriculture (ISPA) updated the definition for precision agriculture in January 2024 (International Society of Precision Agriculture [ISPA], 2024). Depending on the source, it’s common to come across any of these terms being used interchangeably.

In this report, the following terms will be used and defined as follows:

| Term | Definition |
|------------------------------|--|
| Precision agriculture | “Precision Agriculture is a management strategy that gathers, processes and analyzes[sic] temporal, spatial and individual plant and animal data and combines it with other information to support management decisions according to estimated variability for improved resource use efficiency, productivity, quality, profitability and sustainability of agricultural production” (ISPA, 2024). |
| Smart agriculture | “Uses information and communication technologies, such as the Internet of Things (IoT), robotics, and augmented and virtual realities (AR/VR), to improve both the quantity and quality of products while optimizing human labor[sic]” (IEEE, 2022). |
| Digital agriculture | “The use of new and advanced technologies, integrated into one system, to enable farmers and other stakeholders within the agriculture value chain to improve food production. It is characterized by the use of precision and data-driven technologies to assist farmers with real-time and site-specific decision making” (Food and Agriculture Organization of the United Nations [FAO], 2022). |
| Agriculture 4.0 | “Agriculture that integrates a series of innovations in order to produce agricultural products. These innovations englobe precision farming, IoT and big data in order to achieve greater production efficiency” (FAO, 2020). |

These definitions from various international organizations support a common theme that digital agriculture is the overarching term for technological progression in agriculture, which includes within it ‘smart agriculture’ and ‘precision agriculture’. Finally, the significant advancements in digital agriculture of late is what has led experts from around the globe to agree we’re currently in the Agriculture 4.0 revolution. Figure 4 depicts the relationship of these four terms.

The Era of Agriculture 4.0

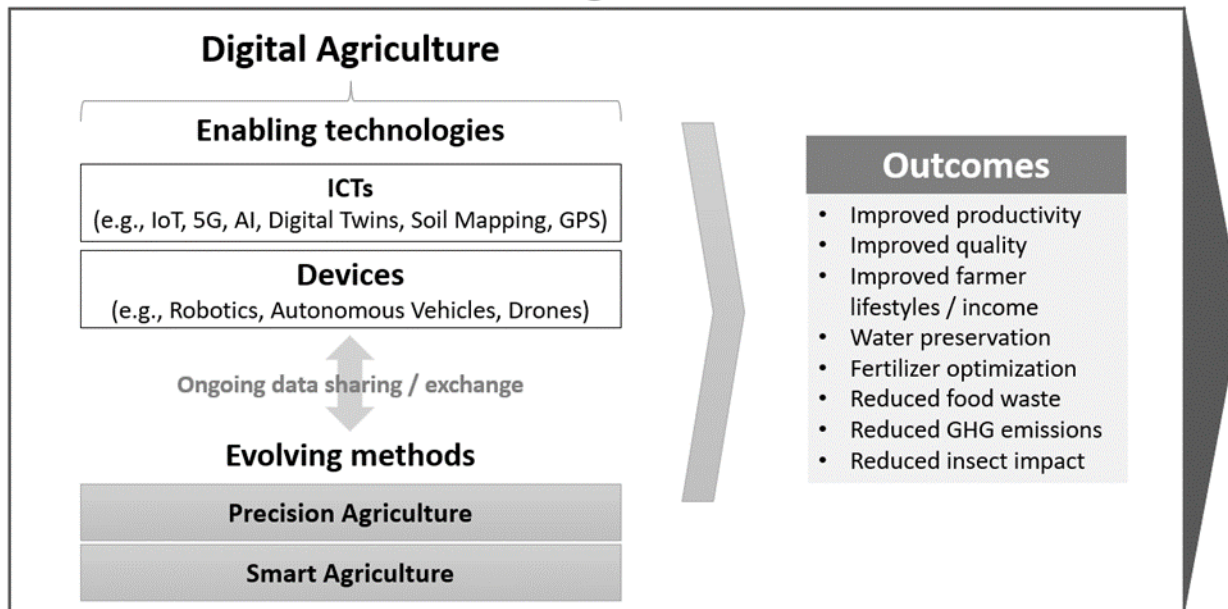


Figure 4: Organizing common terms used interchangeably with ‘digital agriculture’.

14.2. APPENDIX B: SUMMARY OF THE DIGITAL AGENDA INITIATIVES

14.2.1. The European Data Strategy (EDS)

The EDS is one of the initiatives under the European Digital Agenda. It aims to establish a single market for data, promoting competitiveness and data sovereignty. It will encourage data altruism, particularly in Internet-of-Things-generated data, which is crucial for advanced farming technologies, such as precision farming. (European Commission, n.d.g).

14.2.2. European Data Governance Act (EDGA)

The EDGA is another initiative under the Digital Agenda, which seeks to increase trust in data sharing, strengthen mechanisms to increase data availability and overcome technical obstacles to the reuse of data and supports the EDS. The EDGA will support the setup and development of Common European Data Spaces. The EDGA was published in 2020, entered into force in June 2022 and, following a 15-month grace period, was applicable starting in September 2023 (European Commission, n.d.h) (European Commission, n.d.i).

14.2.3. Data Act

The Data Act came into force January 2024. It's a comprehensive initiative to address the challenges and unleash the opportunities presented by data in the EU, emphasising fair access and user rights, while ensuring the protection of personal data. One outcome is increasing legal certainty for companies and consumers engaged in data generation, particularly within the Internet-of-Things framework, by establishing clear rules on the permissible use of data and the associated conditions, while sustaining incentives for data holders to continue investing in high-quality data generation (European Commission, n.d.i).

14.2.4. Common European Data Spaces (CEDS)

CEDS make more data available for access and reuse in a trustworthy and secure environment for the benefit of European businesses and citizens in many strategic fields, including agriculture. Data spaces throughout Europe will gradually be interconnected to form the single market for data (European Commission, 2024b).

14.2.5. Open Data Directive

Supports data reuse and affects data sharing in agriculture and the development of a common data space for agricultural data. It provides common rules for a European market for government-held data. It also introduces the concept and reuse of high-value datasets, which are subject to a separate set of rules ensuring their availability free of charge, in machine readable formats (European Commission, 2024a).

14.2.6. Implementing Act on High-Value Datasets

This Act supports data reuse and affects data-sharing in agriculture and the development of a common data space for agricultural data. The identification and definition of these high-value datasets led to a significant change in the field of open data, as the chosen datasets will be made available in harmonised technical standards. These datasets are grouped in a list of six high-value datasets thematic categories. Geospatial data (the one theme that includes agriculture) provides an interesting preview of what high-value datasets would encompass, including datasets within the scope of the INSPIRE data themes, identifying administrative units, geographical names, addresses, buildings, cadastral parcels, reference parcels and agricultural parcels (European Union, 2022).

14.3. APPENDIX C: COMPARISON OF PRODUCER SUPPORT RECEIPTS (PSE) BETWEEN 2016-2022

The Producer Support Estimate (PSE) as a percentage of gross farm receipts is an important measure because it provides an indicator of the level of support that producers receive from the government as a proportion of their total farm revenues. This includes support through policies that maintain domestic prices at levels above international prices, direct payments to farmers and other forms of support that increase producers' revenues or reduce their costs.

| | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|----------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| EU | 18.6% | 17.9% | 18.9% | 18.6% | 18.3% | 16.3% | 15.1% |
| Australia | 1.7% | 2.7% | 2.4% | 4.2% | 4.0% | 4.4% | 4.3% |
| New Zealand | 0.8% | 0.5% | 0.5% | 0.7% | 1.0% | 0.7% | 0.3% |
| China | 15.6% | 15.0% | 13.0% | 13.3% | 14.8% | 15.2% | 13.4% |
| India | -7.1% | -3.1% | -6.9% | -5.0% | -8.3% | -15.8% | -20.2% |
| Canada | 9.4% | 7.6% | 7.9% | 9.1% | 8.8% | 11.8% | 7.6% |
| United States | 8.6% | 6.6% | 9.4% | 10.2% | 9.3% | 10.4% | 7.2% |
| Mexico | 8.9% | 9.8% | 10.8% | 10.3% | 13.4% | 11.1% | 9.8% |
| Ukraine | -1.5% | -0.8% | 2.1% | 2.9% | 1.4% | 0.1% | -2.6% |
| Alberta | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| OECD avg. | 16.7% | 15.8% | 16.9% | 17.0% | 17.2% | 15.9% | 12.9% |

Table 2: OECD (2023) Producer Support Estimates (PSE) as a per cent of gross farm receipts. [https://data-explorer.oecd.org/vis?tm=producer%20support%20estimate&pg=0&fc=Unit%20of%20measure&snb=16&df\[ds\]=dsDiss eminateFinalDMZ&df\[id\]=DSD AGR POLIND%40DF PSE&df\[ag\]=OECD.TAD.ARP&df\[vs\]=1.0&pd=2013%2C&dq=.A...&ly\[rw\]=REF AREA%2CMEASURE%2CUNIT MEASURE&ly\[cl\]=TIME PERIOD&to\[TIME PERIOD\]=false&vw=tb](https://data-explorer.oecd.org/vis?tm=producer%20support%20estimate&pg=0&fc=Unit%20of%20measure&snb=16&df[ds]=dsDiss eminateFinalDMZ&df[id]=DSD AGR POLIND%40DF PSE&df[ag]=OECD.TAD.ARP&df[vs]=1.0&pd=2013%2C&dq=.A...&ly[rw]=REF AREA%2CMEASURE%2CUNIT MEASURE&ly[cl]=TIME PERIOD&to[TIME PERIOD]=false&vw=tb)

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¹⁵ Alternative link to article: [B - University of Florida 2021 Mexican Govt Support to Agriculture Industry.pdf](#)



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