EMILI

The Future of Farm Work

How Precision Agriculture is Changing Labour and Skills in Manitoba Agriculture

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A research report on labour changes, skills needs, and inclusive adoption

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EXECUTIVE SUMMARY

Technology is changing the nature of farm work in Manitoba. As farms adopt GPS-guided equipment, sensors, data platforms, and other digital tools, farm work is becoming more technical and data-driven. Traditional agricultural knowledge remains essential, but producers, workers, and advisors increasingly need to combine farm experience with digital skills.

This shift is happening at a time when Manitoba agriculture is already under significant workforce pressure. Between 2001 and 2021, the average farm size in Manitoba grew from 891 acres to 1,177 acres, meaning fewer people are now managing larger and more complex operations (Government of Manitoba, 2023, p. 1). At the same time, the sector is struggling to fill roles. In 2022, Manitoba's agriculture sector had approximately 1,300 unfilled positions during peak season, with 40% of employers saying they could not hire all the workers they needed. Almost two-thirds of this group reported lost sales or production delays as a result (Canadian Agricultural Human Resource Council [CAHRC], 2024, p. 65).

Precision agriculture can help manage some of these pressures, but it also raises the skill floor — the minimum competencies needed to participate effectively in farm work. Farmers and workers need to interpret data, operate and troubleshoot equipment, and work with advisors and technical support providers. The workforce challenge facing Manitoba agriculture is therefore not only about finding more people. It is also about ensuring producers, workers, and new entrants have the right training and support to use these tools effectively.

If workforce training and technology adoption supports do not keep pace with sectoral demand, the benefits of digital agriculture may be experienced unevenly. Larger farms or those with stronger access to capital, connectivity, and technical support will be better positioned to adopt and use these tools. Smaller farms, new entrants, and underrepresented groups may face greater barriers. For Manitoba's farming communities, this could deepen existing gaps in skills, income, and access to good jobs.

This report examines how digital agriculture is reshaping farm work in Manitoba, with a focus on how Manitoba can alleviate workforce pressures, strengthen skills training, and support inclusive adoption. It uses precision agriculture as the primary lens within the broader digital agriculture ecosystem,

because field-level tools such as GPS guidance, variable-rate technology, sensors, and data platforms are where the labour and skills implications are most visible in Manitoba crop production. Ultimately, this report argues that technology alone will not solve the province's agriculture workforce challenges. Manitoba must instead treat precision agriculture adoption as part of a broader workforce and community issue, ensuring that producers, workers, students, and rural communities are equipped to benefit from the changes already underway.

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Author note: The author is employed by EMILI and is a co-author of Martin et al. (2026), which is cited in this report. The analysis and recommendations are based on the cited evidence and are presented as a policy research synthesis.



KEY TAKEAWAYS

1. **Expand practical digital agriculture training**
   for producers, workers, students, and advisors.

2. **Scale farm data literacy and data governance education**
   to support confident, responsible use of farm data.

3. **Design adoption supports for smaller farms and underrepresented groups**
   to improve access for rural workers, new entrants, women, Indigenous producers, and newcomers.

4. **Connect demonstration sites with workforce skills**
   to show not only what technology does, but what skills it requires.

5. **Establish a workforce working group under the Manitoba Digital Agriculture Table**
   to coordinate training, demonstration, advisory support, and adoption programming.



SECTION 1: MANITOBA AGRICULTURE UNDER PRESSURE

Manitoba agriculture has been moving toward fewer, larger, and more complex farm operations. Between 2001 and 2021, the average farm size in Manitoba grew by 32.1%, from 891 acres to 1,177 acres, while employment in crop and animal production followed a long-term downward trend associated with consolidation, retirement, and the adoption of labour-saving technologies (Government of Manitoba, 2023, p. 3). The workforce challenge is therefore not simply about finding more workers. It is also about the capacity of fewer people to manage larger operations, more equipment, more business risk, and more specialized tasks.

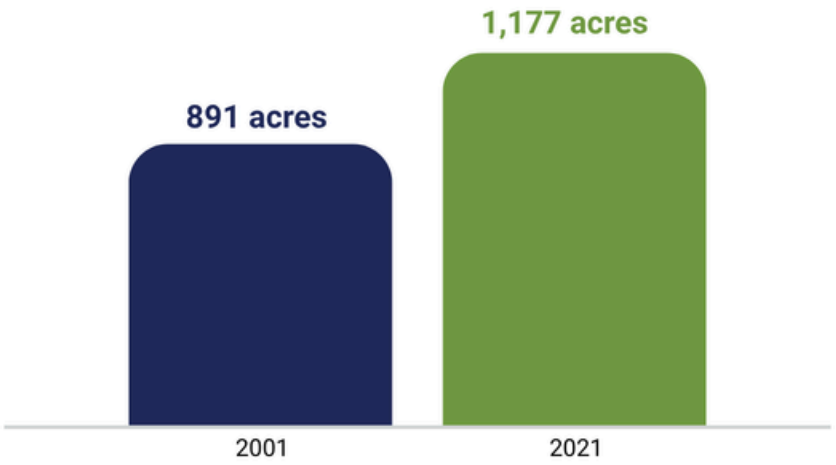
Agriculture's workforce pressures are not temporary. They are only likely to intensify as farms continue to manage retirement challenges and growing operational complexity.

Notably, Manitoba has the highest proportion of young farm operators in Canada, with 11.5% of operators classified as young farmers in 2021, defined by Statistics Canada as operators under the age of 35 (Government of Manitoba, 2025; Agriculture and Agri-Food Canada, 2024b). This younger cohort represents a training opportunity: if digital skills pathways reach producers early in their farm careers, Manitoba may be better positioned to prepare the next generation for increasingly complex farm work.

Manitoba's workforce pressures sit within a broader national labour shortage in agriculture. In 2022, Canadian agriculture had more than 28,200 unfilled positions during peak season, with a vacancy rate of 7.4%, compared with 5.9% across the broader economy (CAHRC, 2024, p. 8). Two in five agricultural employers could not hire all the workers they needed, contributing to an estimated $3.5 billion in lost sales nationally (CAHRC, 2024, pp. 8, 27). For Manitoba farms, these shortages are especially disruptive because planting, spraying, and harvest are concentrated within a short frost-free growing season. Manitoba Agriculture notes that the frost-free period determines the time available for crop production, with spring frost shaping planting dates and fall frost marking the end of the growing season for most crops (Government of Manitoba, n.d.).

Looking ahead, these pressures are expected to intensify. Canada's domestic agriculture labour gap is projected to grow from 87,700 workers in 2023 to more than 101,000 by 2030 during peak season,

Figure 1. Growth in Average Manitoba Farm Size (2001–2021)



+32.1% increase in average farm size over 20 years — fewer farms, larger and more complex operations

Source: Government of Manitoba (2023, p. 3). Trends in employment, labour cost and the agri-food sector.

while nearly 30% of the current workforce is expected to retire (CAHRC, 2024, p. 8).

At the same time, employers are struggling to find workers with the right mix of practical, operational, and job-specific skills (CAHRC, 2024, p. 7).

Manitoba's challenge is therefore not only how many workers are available, but whether the sector has the capabilities modern farm operations require. These pressures matter for precision agriculture because the sector is being asked to adopt more complex tools while managing labour shortages, retirements, and changing skill needs.

Figure 2. Agriculture Labour Shortage Snapshot, Canada (2022)

28,200+	7.4%	$3.5B	101,100
unfilled positions at peak season nationally	vacancy rate — well above national average of 5.9%	estimated lost sales from labour shortages in 2022	projected domestic labour gap by 2030 at peak season

2 in 5 employers could not hire all workers needed · 1 in 3 received no Canadian applications · ~30% of current workforce expected to retire by 2030

Source: Canadian Agricultural Human Resource Council (2024, pp. 7–8). Agriculture labour market forecast 2023–2030: Sowing seeds of change.

SECTION 2: DIGITAL AGRICULTURE AND THE ROLE OF PRECISION AGRICULTURE

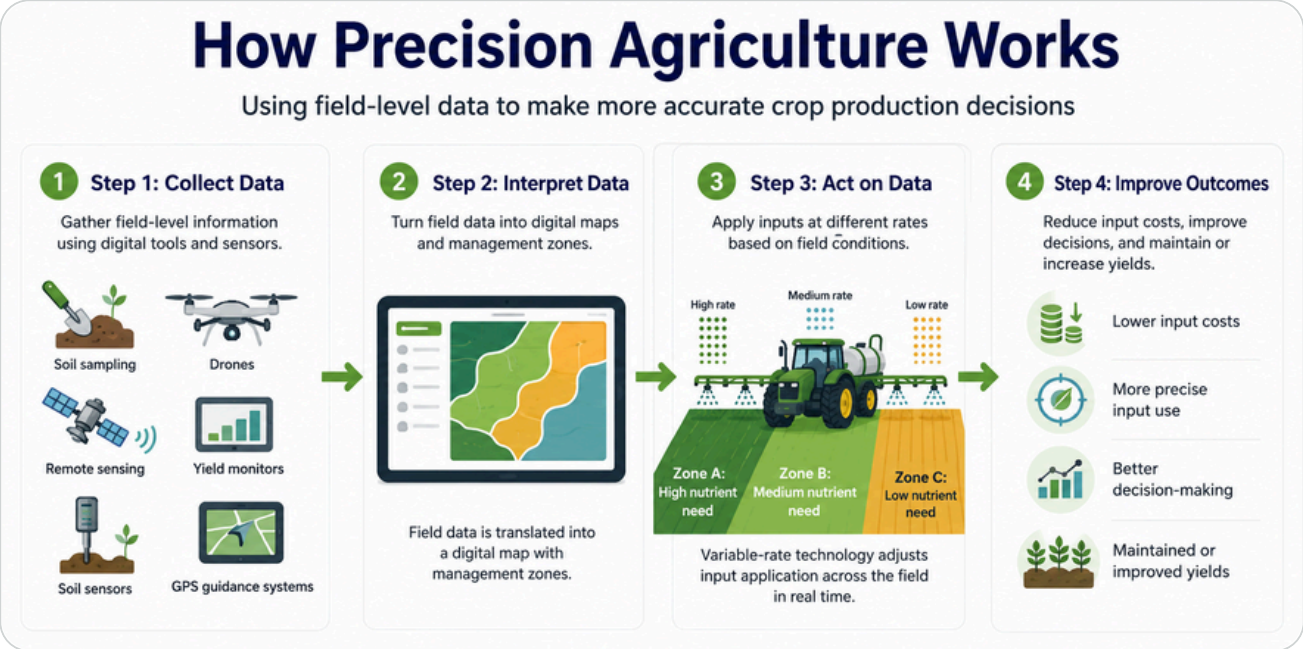
Digital agriculture is a broad and growing field. It covers the full range of digital tools and systems that support farm operations and decision-making, from farm management software and connected equipment to sensors, robotics, AI-driven insights, livestock monitoring tools, traceability systems, and data platforms. These tools offer value beyond yield improvements. They can help farmers streamline operations, manage production risks, lower input costs, and make more informed decisions across the farm (Hiebert et al., 2025, p. 5).

Precision agriculture is an important part of this broader ecosystem. It refers to field-level tools used to manage production with greater accuracy, including GPS guidance systems, yield monitors, variable-rate application technology, remote sensing, drones, soil sensors, and farm data platforms. These tools are especially relevant to crop production because they help farmers collect, interpret, and act on field-level data more precisely than traditional methods allow.

Digital agriculture is not a single product or program. It is an ecosystem of technologies that are reshaping how farms are managed from the ground up.

Precision agriculture connects field-level data to farm decisions. A farmer using variable-rate technology can apply fertilizer at different rates across a field based on soil data, reducing unnecessary input use while maintaining or improving yields. GPS auto-steer can also help cover more acres with greater accuracy and less operator fatigue. These examples show that precision agriculture is not only about equipment; it changes how farm work is planned, how decisions are made, and what information farms rely on.

Precision agriculture is especially relevant in Manitoba because crop production plays a major role in the province's agricultural landscape, including oilseed and grain production as well as high-value crops such as potatoes, where EMILI tests and validates new digital agriculture technologies. Data from the 2021 Census of Agriculture show that 83.6% of oilseed and grain farms in Manitoba used at least one precision technology in 2021, the highest adoption rate among the farm types reported. The same data also show



that technology adoption varies across production systems, including vegetable and melon farms, which reported 44.6% adoption, and livestock operations, where adoption rates were lower (Government of Manitoba, 2021, Table 1, p. 2). For this reason, precision agriculture provides a useful lens for examining labour and skills change in Manitoba agriculture.

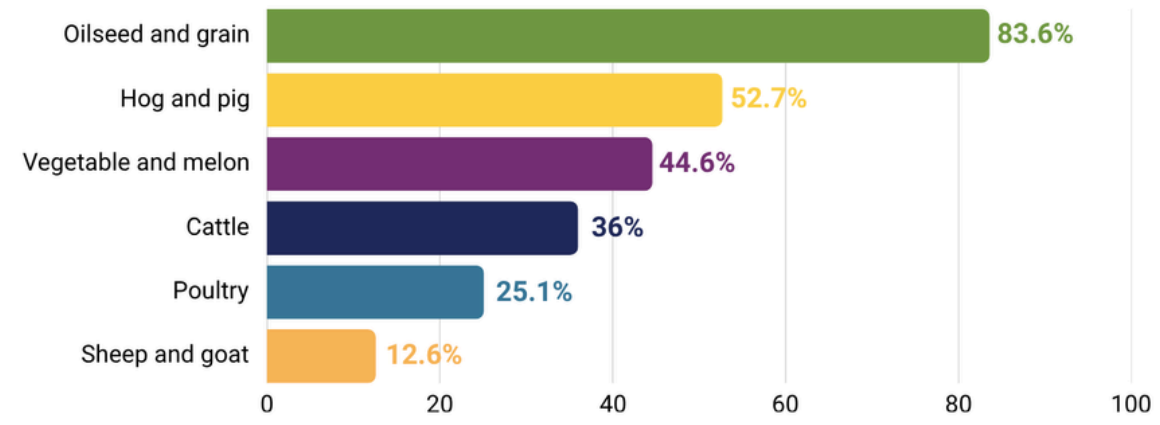
The 2021 Census of Agriculture remains the most appropriate Manitoba-specific baseline because it is the latest comprehensive province-wide source for farm technology adoption. This does not mean adoption has been static since 2021. Statistics Canada has updated the 2026 Census of Agriculture questionnaire to better reflect current on-farm technologies while retaining key questions from 2021 to better support comparability over time (Statistics Canada, 2025; Statistics Canada, 2026). The 2021 data should therefore be read as a baseline, not a complete picture of current adoption.

The baseline shows that technology adoption is already underway in Manitoba, but uneven. Overall, 55.9% of Manitoba farms reported using at least one technology in 2021 (Government of Manitoba, 2021, p. 1). Auto-steer, one of the most widely adopted precision tools, was used by 41.4% of Manitoba farms, with Manitoba ranking second highest in Canada for its use (Government of Manitoba, 2021, p. 2; Statistics Canada, 2022). Adoption was lower among cattle farms at 36%, poultry farms at 25.1%, and sheep and goat operations at 12.6% (Government of Manitoba, 2021, Table 1, p. 2). These differences matter because they

show that precision agriculture is already present in Manitoba, but not evenly distributed across the sector. Research on Canadian crop production confirms that adoption barriers remain important, particularly for more complex tools. Cost, connectivity, uncertain returns on investment, data governance concerns, and skills gaps can all limit uptake (Mitchell et al., 2021, p. 413). Farm size also matters, as larger operations often have more acres over which to spread costs and greater access to advisory support (Hiebert et al., 2025, p. 10). The next sections therefore examine not only what precision agriculture does, but how it changes work and why those changes may affect farms and workers unevenly.

Figure 3. Technology Adoption by Farm Type in Manitoba (2021)

Percentage of farms reporting use of at least one selected agricultural technology.



Source: Government of Manitoba (2021, Table 1, p. 2). Technology adoption and production of renewable energy in Manitoba.

SECTION 3: HOW PRECISION AGRICULTURE CHANGES FARM WORK

When a farm adopts precision agriculture, work does not simply disappear; it is reorganized. Some routine tasks may be reduced or automated, while new tasks emerge around data interpretation, equipment calibration, troubleshooting, and decision-making. This reflects what Acemoglu and Restrepo (2019) describe as automation's dual effect: some tasks are displaced, while new ones are created (pp. 3–4). In agriculture, the result is a higher "skill floor," meaning the minimum set of skills needed to participate effectively in farm work (see Figure 4).

Precision agriculture does not replace practical farm knowledge. It adds a technical and data-driven layer to the skills producers and workers already need.

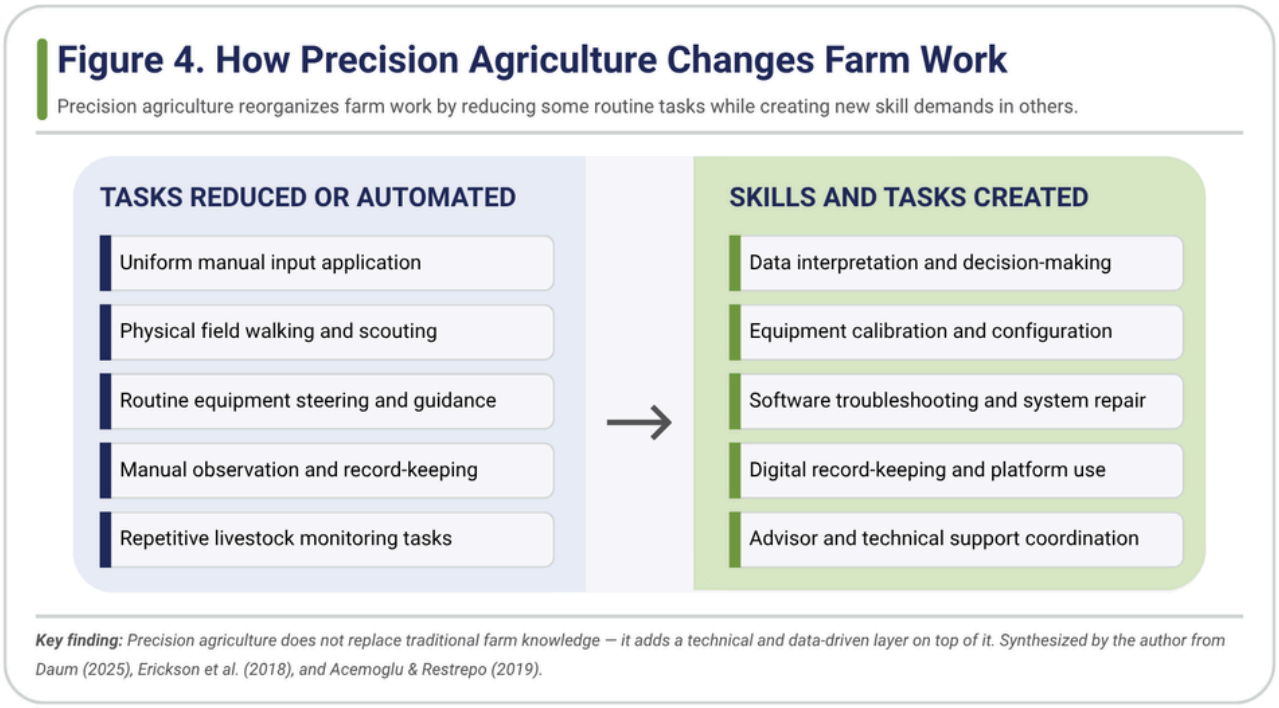
From routines to decisions

Farm work has traditionally followed seasonal patterns, including seeding, spraying, harvesting, and crop monitoring. These tasks have long depended on experience, observation, and practical farm knowledge. Precision agriculture does not replace this foundation. Instead, it adds a technical and data-driven layer to existing agricultural practices.

A producer using variable-rate application technology, for example, is not simply applying inputs uniformly across a field. They are working with soil sampling data, interpreting spatial variability maps, and making input decisions that require both agronomic judgement and digital information. This can improve input efficiency and crop outcomes when done well, but it also makes mistakes more consequential if data are misread or tools are used incorrectly.

Daum (2025) captures this dynamic by explaining that digital agriculture may lead to deskilling, reskilling, or upskilling, depending on how technologies are designed and how users interact with them. These outcomes are not predetermined. They depend on whether producers and workers are positioned as active decision-makers or as passive recipients of automated outputs, as well as whether they have the skills, confidence, and support needed to use these tools meaningfully.

A Manitoba-based example is EMILI's work with Geco Strategic Weed Management at Innovation Farms. The project uses artificial intelligence, satellite imagery, historical field data, and agronomic models to predict weed zones, including herbicide-



resistant weed patches. EMILI's project work has also examined variable-rate inputs, including seeding and residual herbicide rates, to support targeted interventions in the weediest areas of a field rather than relying on blanket applications (EMILI Innovation Farms, n.d.). The value of this tool depends not only on the technology itself, but on whether producers and workers can interpret the prescription map and apply agronomic judgement. In this way, it changes the skills needed to make good decisions.

New demands on equipment operation and maintenance

Precision agriculture changes what it means to operate farm equipment. Workers using GPS-guided seeders, yield monitors, drones, or connected sensors need mechanical knowledge, digital literacy, and problem-solving ability. Academic research has shown that the ability to install, calibrate, troubleshoot, and repair equipment is among the competencies most consistently sought by precision agriculture employers (Erickson et al., 2018, pp. 1–2). As on-farm automation expands, routine manual tasks may become more vulnerable to displacement, while non-routine cognitive tasks, including monitoring, troubleshooting, and decision-making, become increasingly important to productivity (Marinoudi et al., 2024).

Greater reliance on advisors and technical support

Precision agriculture also changes who farmers and workers need to work with. As tools become more technically complex, producers increasingly rely on

agronomists, equipment dealers, software providers, data consultants, and technical service providers to help them capture value from the technologies they adopt. Rotz et al. (2019, p. 115) identify this as a significant structural shift, one that creates new dependencies between farms and external technical expertise. It also raises important questions about whether small and mid-sized operations can access the same quality of support as larger farms.

Technology adoption challenges are also workforce challenges: farms need practical training, trusted advice, and ongoing technical support to use digital tools effectively.

This growing reliance on external advisors is not necessarily problematic. Strong advisory relationships can help producers make better decisions and use technology more effectively. However, when support is unavailable, unaffordable, or poorly matched to a farm's context, producers may find themselves with tools they cannot fully use. In these cases, the technology may be physically present on the farm, but its potential remains unrealized.

Taken together, these changes turn what may appear to be a technology adoption challenge into a workforce challenge. The central issue is not whether precision agriculture has value, but whether Manitoba's workforce and training systems are prepared for the kinds of farm work it creates. If precision agriculture raises the skill floor, the next question is whether all farms and workers are equally positioned to meet it.

The reasons are structural. Research has consistently found that farmers' technology adoption decisions are driven more by real-world constraints than by an aversion to change (Hiebert et al., 2025, p. 6).



SECTION 4: UNEVEN ADOPTION AND WORKFORCE ACCESS

Larger farms have more acres over which to spread upfront costs, making returns on investment more predictable. They may also have more reliable connectivity, stronger relationships with equipment dealers and agronomists, and greater capacity to hire technical support.

Smaller farms, by contrast, may face several barriers at once, including tighter margins, weaker connectivity, limited advisory access, and fewer acres over which to absorb the cost of new tools.

Table 1 provides more detail on barriers to adoption and shows why technology adoption challenges also become training, trust, and skills issues. These barriers matter because they shape who benefits from digital agriculture and who has opportunities to build new skills. Mitchell et al. (2021) confirm that adoption barriers are particularly concentrated in Canadian farm operations, where cost, knowledge gaps, and limited access to advisory networks can compound one another (p. 413). If technical and data-oriented roles

Table 1. Adoption Barriers and Workforce Implications

Adoption barrier	Workforce implication
Connectivity gaps	Limits access to real-time tools and remote support, particularly for rural workers and smaller farms
ROI uncertainty	Discourages investment in training alongside tools, deepening skills gaps on farms with tighter margins
Data governance concerns	Reduces willingness to adopt data platforms, limiting workers' access to digital decision-making roles
Skills and advisory gaps	Producers acquire tools they cannot use effectively; workers lack pathways to emerging technical roles
Technology efficacy doubts	Slows adoption among cautious producers, reducing demand for trained technical workers in the sector

Synthesized by the author from Hiebert et al. (2025, p. 13), Martin et al. (2026, p. 7), and Mitchell et al. (2021, p. 413).

concentrate mainly in larger operations, workers in smaller or less digitally equipped farms may have fewer opportunities to develop these skills on the job.

When access to capital, connectivity, training, and advisory networks is uneven, the benefits of precision agriculture are uneven too.

Groups facing greater barriers to adoption

Beyond farm size, several groups may face compounding barriers as precision agriculture becomes more important to farm resilience and competitiveness. Producers who are closer to retirement may face different cost-benefit calculations around investing in new tools or training, while early-career farmers often face high capital costs as they establish operations. Rural and seasonal workers may be more exposed to automation if their roles involve routine manual tasks. Women, Indigenous producers, and newcomers may also face additional barriers related to access to land, credit, training, and advisory networks (Toronto Metropolitan University et al., 2025). Rotz et al. (2019, p. 118) show that agricultural technologies can intensify inequalities in rural labour and communities when adoption is not supported equitably.

Manitoba-specific data on precision agriculture adoption rates and training access among these groups remains limited. This makes it difficult to design targeted programs or measure equity outcomes. However, the lack of detailed data should itself be treated as part of the workforce and adoption challenge. Without better information about who has access to training, advisory support, and digital tools, programs risk serving the farms and workers already best positioned to benefit.

Daum (2025) argues that the outcomes of agricultural digitalization are not predetermined. They depend on framework conditions, including how technologies are designed, whether training is available, and whether trusted support structures exist. Manitoba therefore has an opportunity to shape these conditions deliberately. The goal should not only be to increase adoption, but to ensure that producers, workers, and rural communities have a realistic pathway to participate in the changes underway.

SECTION 5: TRAINING, ADOPTION SUPPORT, AND MANITOBA'S OPPORTUNITY

All the dynamics explored up to this point raise a practical question for program and policy design: what do producers, workers, and new entrants need in order to navigate precision agriculture effectively? The answer is not simply more technology. It is practical training, trusted support, and opportunities to see how digital tools work under real farm conditions.

Access to precision agriculture tools is necessary but not sufficient. Producers can acquire GPS guidance systems, variable-rate technology, or farm data platforms and still fail to capture their full value if training is not connected to real farm decisions. Hiebert et al. (2025) note that a strong agricultural technology, or agtech, sector does not automatically lead to robust on-farm use of digital technologies; meaningful adoption requires support at the point of use, not only at the point of purchase (p. 5).

Training should therefore focus on practical capabilities such as interpreting yield maps, managing digital records, troubleshooting equipment, communicating with advisors, and applying data to field-level decisions. Erickson et al. (2018) found that valued competencies across precision agriculture roles include technical skills as well as integrating information, making decisions under uncertainty, and adapting tools to specific farm conditions (pp. 1–2). Programs should also be modular, flexible, and accessible to rural producers, older operators, seasonal workers, and others with limited time or connectivity.

The role of demonstration

Farmers respond to proof. Abstract claims about productivity gains are less persuasive than visible, locally relevant demonstrations showing that a tool works under real Manitoba conditions. Hiebert et al. (2025) identify commercial-scale technology testing as a critical enabler of adoption, not because farmers resist innovation, but because they are pragmatic decision-makers who need evidence that a tool will perform in their specific context before taking on financial risk (p. 19).

EMILI's Innovation Farms Grosse Isle site is located on a commercial grain and oilseed farm near Winnipeg and is designed for this purpose. It provides a real-world setting where producers, students, policymakers, and entrepreneurs can observe precision agriculture tools operating at commercial

scale, reducing perceived risk and building confidence in locally demonstrated results (Martin et al., 2026, p. 8). The opportunity is to connect this asset more deliberately to workforce development by using the site not only to demonstrate what technology does, but also to show what the work looks like, what skills it requires, and what careers in digital agriculture can involve.

Manitoba's existing ecosystem

Manitoba is not starting from scratch. The province already has a meaningful set of organizations and programs supporting the digital agriculture transition. They could have even more impact if they are better connected to one another.

EMILI is one key actor, combining technology demonstration, farm data literacy programming, applied research, and industry engagement. Its Fundamentals of Farm Data program offers free, accessible training in farm data literacy and governance, providing a foundation for digital competency across the sector (EMILI Innovation Farms, 2024).

Other Manitoba actors also have relevant roles to play. Assiniboine College offers agriculture-related programming, including an agribusiness diploma focused on the science, business, and technology aspects of agriculture, and has partnered with Palette Skills to deliver an eight-week Digital Agriculture Fundamentals course for mid-career professionals in Manitoba (Assiniboine College, 2024). Agriculture in the Classroom Manitoba supports early agriculture awareness and career exposure through classroom resources and programs such as Foundations of Manitoba Agriculture (Agriculture in the Classroom Manitoba, n.d.). Producer organizations, including Keystone Agricultural Producers and Manitoba Canola Growers, provide trusted networks through which programs can reach producers. Equipment dealers and agronomists are also important because they are often the first point of contact for producers considering new tools.

Government programs delivered through the Sustainable Canadian Agricultural Partnership provide funding pathways for digital adoption and skills development. However, Hiebert et al. (2025) suggest that these programs could be strengthened through clearer strategic focus and more coordinated delivery (pp. 10–11). Martin et al. (2026) identify fragmentation as one of the most significant barriers to scaled adoption in Canada, with strong individual actors often operating without the shared spaces and mechanisms needed to align their efforts (p. 18). Manitoba's scale is an advantage in this respect. Coordination is more achievable at the provincial level, and the province's existing actors are well placed to align their efforts if given a shared structure to work within.

SECTION 6: RECOMMENDATIONS

The evidence in this report points to a clear conclusion: Manitoba should treat precision agriculture adoption as a workforce development challenge, not only as a technology access challenge. The following five recommendations are practical, Manitoba-relevant, and grounded in the report's analysis.

1. Expand practical digital agriculture training for producers, workers, students, and advisors.

Training in precision agriculture should move beyond awareness-raising and focus on task-connected skills. This includes interpreting yield data, troubleshooting connected equipment, managing digital records, and applying field-level information to farm decisions. Programs should be modular, flexible, and timed around rural and seasonal realities so they can reach producers and workers when participation is most feasible.

2. Scale farm data literacy and data governance education across the sector.

Data literacy is foundational to meaningful participation in digital agriculture. Producers and workers need practical guidance on how farm data is collected, used, shared, and protected. EMILI's Fundamentals of Farm Data program provides a strong starting point that could be scaled, embedded in other training, and connected to clearer data governance supports. This is not only a technical issue; it is also a trust issue.

3. Design adoption supports for smaller farms, rural workers, new entrants, and underrepresented groups.

Funding, technical assistance, and advisory services should be designed to reach farms and workers facing the greatest barriers. This includes smaller operations, remote producers, rural and seasonal workers, women, Indigenous producers, newcomers, and beginning farmers. Supports should address cost, connectivity, advisory access, and delivery barriers so that adoption programs do not only benefit the operations already best positioned to participate. For producers in areas with limited internet access, offline-capable tools and in-person delivery models are especially important. Designing targeted supports will also require better data: Manitoba-specific information on who has access to training, advisory services, and digital tools by producer type is currently limited, and closing this data gap should be treated as part of the equity agenda.

4. Use commercial-scale demonstration sites to connect technology adoption with workforce skills.

Manitoba producers are more likely to invest in tools they have seen working under real farm conditions. EMILI's Innovation Farms provides an existing platform for this kind of commercial-scale demonstration. Demonstration programming should show not only what precision agriculture tools do, but also what skills they require, how workers interact with them, and what careers in digital agriculture can involve.

5. Establish a workforce working group within the Manitoba Digital Agriculture Table to coordinate training, demonstration, advisory support, and adoption programming.

Training, demonstration, advisory services, and adoption supports will have greater impact if they are aligned rather than operating independently. A workforce working group under the existing Manitoba Digital Agriculture Table could bring together EMILI, Manitoba post-secondary institutions, producer organizations, government, and industry to identify gaps, align programming, and track progress annually. EMILI could help initiate this working group alongside government support for dedicated coordination capacity.



CONCLUSION

Precision agriculture is changing the nature of farm work in Manitoba.

The issue is not simply whether farms are acquiring new tools, but whether producers, workers, students, and new entrants are being prepared to use those tools effectively and equitably.

If adoption continues to concentrate among larger, better-resourced operations, the benefits of digital agriculture may also concentrate there. Smaller farms, rural workers, and underrepresented groups will need practical training, trusted advisory support, data literacy, and accessible demonstration opportunities to participate meaningfully.

Manitoba has the organizations, expertise, and assets needed to respond. The task now is to connect those pieces deliberately so that precision agriculture strengthens productivity while also building a more inclusive and digitally capable agricultural workforce.



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This report is based on secondary research, including government data, labour market forecasts, academic literature, and policy reports. It does not include original interviews, surveys, or farm-level fieldwork. Some Manitoba technology adoption data are drawn from the 2021 Census of Agriculture, meaning the report should be read as a policy scan and synthesis rather than a complete measurement of current adoption patterns.

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