A Report For:

Leading the Herd

AI, Insight, and the Next Agricultural Revolution

by Paul Windemuller

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Executive Summary

Artificial intelligence (AI) is the most transformative force to enter livestock agriculture since mechanization. Like electricity in the early 20th century, AI is not a single tool but an enabling layer, one that will shape every part of farming, from feeding and health to labor and finance.

This paper, grounded in my Nuffield Farming Scholarship travels across fifteen countries, walks through the state of AI in livestock production today, the roadblocks I witnessed firsthand, and the progress we must make as an industry to unlock its full potential. It explores not only what the future of AI-powered farming could look like, but also the practical steps we can take together to turn that vision into reality.

Three frameworks emerge from this research:

- **The AI Yield Gap:** the widening divide between farms that merely collect data and those that act on it. This gap will define winners and losers in the livestock sector over the next decade.
- **The Livestock AI Readiness Index (LARI):** a diagnostic tool to help farmers and policymakers assess their preparedness for AI adoption.
- **The Holistic Insight Threshold (HIT):** the tipping point where multiple data streams converge into compound insights that transform strategy, not just individual decisions.

Alongside these frameworks, I propose a structural shift: AI Data Stewardship Cooperatives. These farmer-owned organizations would ensure producers retain ownership of their data, co-develop digital infrastructure, and capture value from the insights their herds generate.

Real-world examples; from virtual fencing in New Zealand to microbiome-guided feeding in Israel, drone mustering in Australia, and AI-powered parlor monitoring in Texas, show that this future is already unfolding. Yet barriers remain; fragmented systems, poor data quality, cultural resistance, limited infrastructure, and regulatory lag.

In the end the central message is simple: AI will not replace farmers, but it will redefine what successful farming looks like. Those who prepare intentionally will not only survive this transition, they will lead the herd.

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Foreword

This report represents a pivotal chapter in my life; both as a farmer and as a leader in agriculture.

I didn't grow up on a generational farm. My wife Brittany and I started our dairy, Dream Winds Dairy, from scratch in 2014 with little more than a shared dream and a deep sense of purpose. Over the years, through hands-on learning, hard lessons, and a relentless pursuit of better systems, I developed a passion for improving how farms operate; not just for efficiency, but for the health of animals, land, and people.

My first exposure to the Nuffield network was back in 2008 when Andy MacFarlane introduced me to several scholars during a study abroad semester in university I had in New Zealand. At the time, it felt out of reach. But the idea never left me, it was always on my bucket list. Years later, after a decade of building a farm, launching businesses, and beginning to shape a voice in agriculture, I realized it was time to step back and invest deeply in learning again. Nuffield offered a unique opportunity to do just that, on a global scale.

I applied with a very specific question in mind: How can artificial intelligence (AI) reshape the ruminant livestock sectors to be more sustainable, profitable, and people-centered? I had already seen glimpses of this on my own farm through robotic milkers and automated health monitoring systems. But I knew the impact could be far greater than most people realized.

This scholarship took me to fifteen different countries including Sweden, Germany, the UK, Ireland, Brazil, Australia, and New Zealand. It led me to engage in numerous conversations with farmers, technologists, researchers, and investors. Each encounter added layers of nuance, caution, and excitement to my understanding of AI's role in agriculture.

More than anything, this journey has solidified my belief that the future of livestock farming isn't about machines replacing people; it's about systems that help people make better decisions, co-intelligence. It's about stewardship, not just of land and animals, but of data, insight, and relationships.

This report is a product of those experiences. It's not a technical manual but it is my attempt at a roadmap and a call to action. I hope it inspires others in agriculture to step into the unknown, ask better questions, and boldly lead the herd into a new era of insight and innovation.

Acknowledgments

This paper was made possible through the support, insight, and encouragement of many individuals who generously shared their time, expertise, and belief in the future of livestock agriculture.

I would first like to thank my wife and children, who supported me during my travels and stepped up in every way on our family farm. This work would not have been possible without their love, patience, and shared belief in our mission.

I am grateful to Andy MacFarlane, who has not only served as a lifelong mentor but was also the person who first introduced me to the Nuffield program back in 2008. His influence shaped both my thinking and this journey.

To Craig Piggott and the team at Halter, thank you for your hospitality, openness, and deep conversations about the future of pasture management and livestock behavior. Your work is reshaping what's possible in grazing systems, and it had a profound impact on my understanding of integrated AI platforms.

To Aidan Connolly, thank you for the introductions that opened global doors and for your thought-provoking interview on AI's role in agriculture—it sharpened my vision for this paper and the industry's future.

To Paul Lofgren, CEO of Delaval, who graciously gave of his time in order to give me an amazing experience and insight into the work they are doing as a dairy equipment manufacturer with AI in many aspects of a dairy farm. His hospitality is world-class and the day with him and his team was at the top of the list for Nuffield visits.

To Forbes Elworthy, Founder of Map of Ag and Craigmore Sustainables, whose spirit of curiosity and commitment to learning left in me a lasting impression. I am deeply grateful for your insights, the intensity and depth of our conversations, and your gracious hospitality. Your perspective helped shape and refine several of the ideas presented in this paper.

To many a kindred spirit who I met along my journey in the possibilities of AI in agriculture. Their insights helped to shape and develop findings that contributed to this paper.

To the International Farm Management Assocation (IFMA) for your support that made it possible to attend the IFMA Congress in Canada.

And to the Nuffield International Farming Scholars program, thank you for the opportunity to explore, connect, and contribute to the future of agriculture through this research. Your global network is a force for good in a rapidly evolving world.

Abbreviations

AI – Artificial Intelligence
LARI – Livestock AI Readiness Index
ROI–Return-on-Investment
HIT – Holistic Insight Threshold
LLM – Large Language Model

Objectives

This report aims to explore the transformative potential of artificial intelligence (AI) in the livestock sector by focusing on the following objectives:

- Assess the current and emerging applications of AI in livestock systems across health, reproduction, feeding, labor, and management practices.
- Identify key barriers to adoption—including data quality, system integration, cultural resistance, infrastructure limitations and policy; and explore strategies to overcome them.
- Develop practical frameworks to help farmers and industry stakeholders evaluate and prepare for AI adoption.
- Investigate real-world global case studies that demonstrate how AI is reshaping farm strategy, labor dynamics, and system-level decision-making.
- Propose a model to ensure farmers retain control and share in the value of the data their operations generate.

1. Introduction: The Inflection Point

We are standing at one of the most significant turning points in the history of livestock agriculture. It is not just a shift in tools, but a revolution in how decisions are made. Artificial intelligence (AI) is emerging as a transformative force, enabling farms to move from intuition-led management to insight-led ecosystems.

As Jeff Bezos once said, AI is like “a horizontal enabling layer,” much like electricity in the early 20th century. At first, electricity seemed like a luxury. Over time, it became the invisible infrastructure behind every modern process, from lighting and manufacturing to computing. AI is following a similar trajectory. It will touch every aspect of life and of agriculture, from feed optimization to animal welfare, and will increasingly separate the farms that thrive from those that struggle to adapt.

But AI isn’t just software. It’s a reflection of how our industry is evolving. Success in this new era requires more than technology; it demands data maturity, cultural openness, compute infrastructure, and visionary leadership.

Today’s livestock farm is a complex biological engine, generating massive amounts of data across reproduction, nutrition, genetics, environment, labor, and finance. What

we've lacked, until now, is a system that turns that complexity into clarity. This is where AI fits.

This paper is built around a central thesis: AI will be the most powerful force in the sustainable livestock systems of the future, not just automating decisions, but helping people make better decisions in complex environments.

Throughout my Nuffield journey, I traveled across continents, interviewed leading technologists, and observed farms where AI was flourishing and where it was floundering. What I found is that the future isn't evenly distributed but the principles for preparing for it are increasingly clear.

While this report highlights case studies and applications of AI across livestock systems, it also weaves in the core principles that determine whether these technologies succeed or fail in practice. Throughout the report, I explore how AI's two phases, training and inference, translate from the office to the barn, how data quality and labeling determine the reliability of insights, and why explainability and trust are just as critical as accuracy for adoption. I examine the importance of scalability, interoperability, and feedback loops, showing how models improve only when farm teams act on and reinforce AI's predictions. Ethical considerations such as bias, fairness, and data stewardship are treated not as afterthoughts but as essential design principles for the future of livestock AI.

By grounding this paper in both the practical realities of adoption and the deeper principles of artificial intelligence, I aim to provide a roadmap that is as relevant to farmers and advisors as it is to policymakers, technologists, and investors.

2. My Journey in AI and Livestock

When my wife and I started our dairy farm from scratch in 2014, we didn't come from generations of livestock producers. I wasn't the kind of farmer who could walk into a barn and instinctively know which cow was off her feed or in heat. Those skills, so critical to animal welfare and profitability, were my weakest areas.

Less than three years in, everything changed. We installed robotic milkers and sensor-based monitoring systems, and suddenly I wasn't relying on my eyes alone or the intuition I desperately lacked. The system analyzed real-time behavioral and physiological data, telling me which cows to breed and which ones to check for early health issues. To my surprise, it was often more accurate than even the most seasoned herdsmen I'd worked alongside.

Picture of my farm, Dream Winds Dairy in Coopersville, MI USA

That was the moment I became captivated by AI; not because it replaced me, but because it elevated my ability to manage with precision.

Alongside these insights came challenges. On our farm, I experienced firsthand how resistance to new tools can derail even the best technology. If team members don't trust or understand a system, no amount of innovation delivers ROI. Poor data quality, what one fellow Nuffield Scholar aptly called "doggy data", can turn a promising model into a source of false confidence and make for an expensive lesson.

Yet one of the greatest lessons I've learned is this: AI closes the gap between intuition and evidence. It empowers less experienced workers to make good decisions, democratizing high-level herd management. AI doesn't automate tasks; it raises the floor of decision quality across the entire team.

It's this potential to augment people, not replace them, which convinced me AI will be a cornerstone of the livestock systems of the future.

3. The Emerging Frameworks

Why AI Matters in Livestock

At its core, AI is about converting complexity into clarity. Modern livestock farms generate staggering amounts of data across reproduction, feed, health, genetics, and labor. Yet raw data alone is useless without interpretation. AI transforms noise into patterns, and patterns into actionable decisions. It shifts the role of the farm manager from reactor to strategic systems thinker.

AI can create value through five key levers:

3.1 Efficiency

AI can continuously fine-tune operations based on real-time data; minimizing feed loss, adjusting milking routines, and optimizing barn environments. These efficiency gains aren't theoretical; they translate into measurable improvements in margins, resource use, and sustainability.

3.2 Longevity

AI detects subtle health changes before clinical symptoms appear, allowing for earlier intervention. This extends productive lifespan, reduces culling rates, and lowers replacement costs. A cow that lasts longer and performs better is a direct return on AI's predictive power.

3.3 Labor

Labor shortages remain one of the livestock industry's biggest challenges. AI doesn't eliminate the need for people, but it empowers a leaner team to do more with less. Even less-experienced workers can succeed with the guidance of timely insights, democratizing high-level herd management.

3.4 Insight

The most underrated aspect of AI isn’t what it automates but what it reveals. By integrating data streams from feed, genetics, reproduction, and environmental factors, AI provides a holistic view of the system. It enables managers to see interactions and trade-offs invisible to the naked eye.

3.5 Profitability

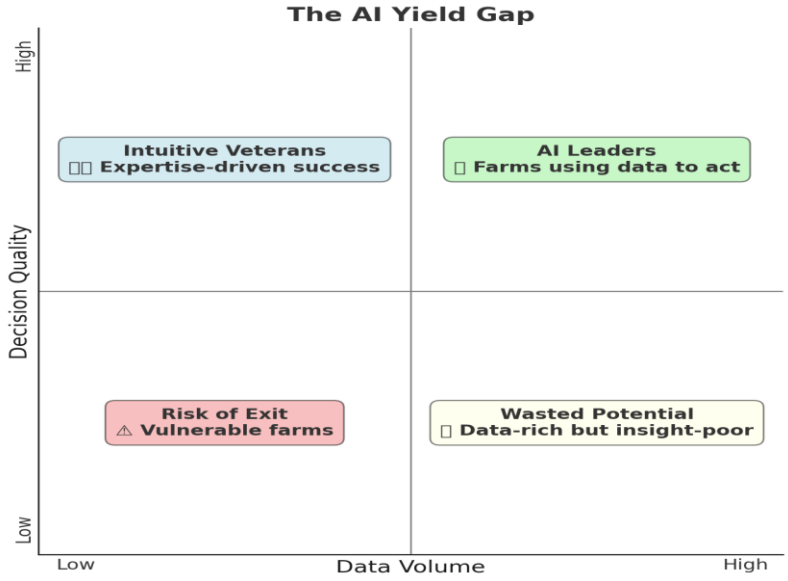
While sustainability and animal welfare are critical, they ultimately hinge on economic viability at the farm level. AI solutions that deliver clear, measurable returns, whether through improved feed efficiency, reproductive performance, or herd health, will drive widespread adoption. Profitability acts as the filter through which all other benefits are evaluated.

4. Beyond the Levers: The AI Yield Gap

Despite the capabilities of the key levers to adding value, most livestock farms today fall into one of two categories:

1. Those that collect data, and
2. Those that act on it.

The gap between these two groups; the difference between technological capacity and behavioral execution, is what I call the AI Yield Gap. It's a performance chasm that will define winners and losers in the livestock sector over the next decade.



In cropping agriculture, researchers have long measured the "yield gap", the difference between what is theoretically possible under optimal conditions in a field and what farmers achieve in practice. A similar dynamic is now unfolding in livestock in terms of data.

Across the dairy sector, farms are collecting more data than ever: sensors on cows, robotic milking systems, feed and forage analytics, genomic profiles, and health records. In theory, this data could allow us to close the gap between average performance and optimal biological or economic potential. Yet the reality is that most farms are still only scratching the surface of what AI-driven insights could deliver.

The AI Yield Gap therefore represents the difference between the potential improvements available through advanced AI modeling of livestock systems and the

actual performance outcomes realized on farms today. This gap persists for several reasons which I will explain in more detail in the section titled “Roadblocks”.

Closing the AI Yield Gap is not simply about installing new sensors or software. It requires coordinated innovation: farmer-controlled data platforms, transparent AI models, skilled advisors who can interpret outputs, and business models that share value fairly between farmers, vendors, and downstream partners.

If successful, the effect is that dairy farms could achieve higher milk yields with less feed, lower emissions, earlier disease detection, and more resilient systems overall. The challenge is not just technical but holistic; aligning incentives, governance, and trust so that the latent value of AI is realized in practice.

5. The Global AI Hype Cycle

Every new technology follows a predictable path: initial excitement, inflated expectations, disappointment, and, if it survives, eventual widespread adoption. Artificial intelligence in livestock is no exception.

To understand where we are on this journey, the Gartner Hype Cycle is a useful framework. It charts emerging technologies through five stages:

5.1 Technology Trigger

This is where AI first entered the livestock conversation. Robotic milking, heat-detection sensors, and early experiments with computer vision and machine learning created curiosity about what AI could unlock.

Example: The introduction of robotic milking systems was a watershed moment. Farmers were suddenly able to milk cows without human hands, and the idea of “smart barns” captured imaginations globally. These systems hinted at something bigger: if machines could automate milking, could they also monitor health, optimize feeding, and even make decisions?

This moment triggered the industry-wide conversation about AI; not just as hardware but as an intelligence layer for farm management.

5.2 Peak of Inflated Expectations

Startups promised transformational results, and early adopters leapt in, expecting silver bullets. At this stage, hype often outpaces reality.

Example: Early wearable sensors were touted as revolutionizing herd health. While some delivered, others faltered due to poor integration, generic insights, or impractical designs for real-world farm environments.

5.3 Trough of Disillusionment

Reality sets in. Farmers struggled with fragmented systems, unreliable data, resistance from employees, and high capital costs. When outcomes failed to match expectations, confidence in AI wavered.

Example: High dollar cloud-based software programs that lacked connectivity and would not sync devices.

5.4 Slope of Enlightenment

I believe this is the phase we are coming upon. The tools are improving. Farmers are learning where current AI tools work best and realize that success depends on clean data, skilled teams, and system integration, not just the tech itself.

Example: Predictive health monitoring platforms are reducing disease impact or feed issues by days but only on farms where the team is trained to act on the alerts.

5.5 Plateau of Productivity

In this stage, AI becomes normalized. It's no longer a novel adoption; it's an expected part of good farm management.

Example: Heat detection via wearables has moved from an innovative luxury to a standard tool in many dairy operations, essential for reproductive performance.

Cutting Through the Noise: Is It Really AI?

One theme I encountered repeatedly in my global research was skepticism about whether the tools marketed as "AI" truly deserve the name.

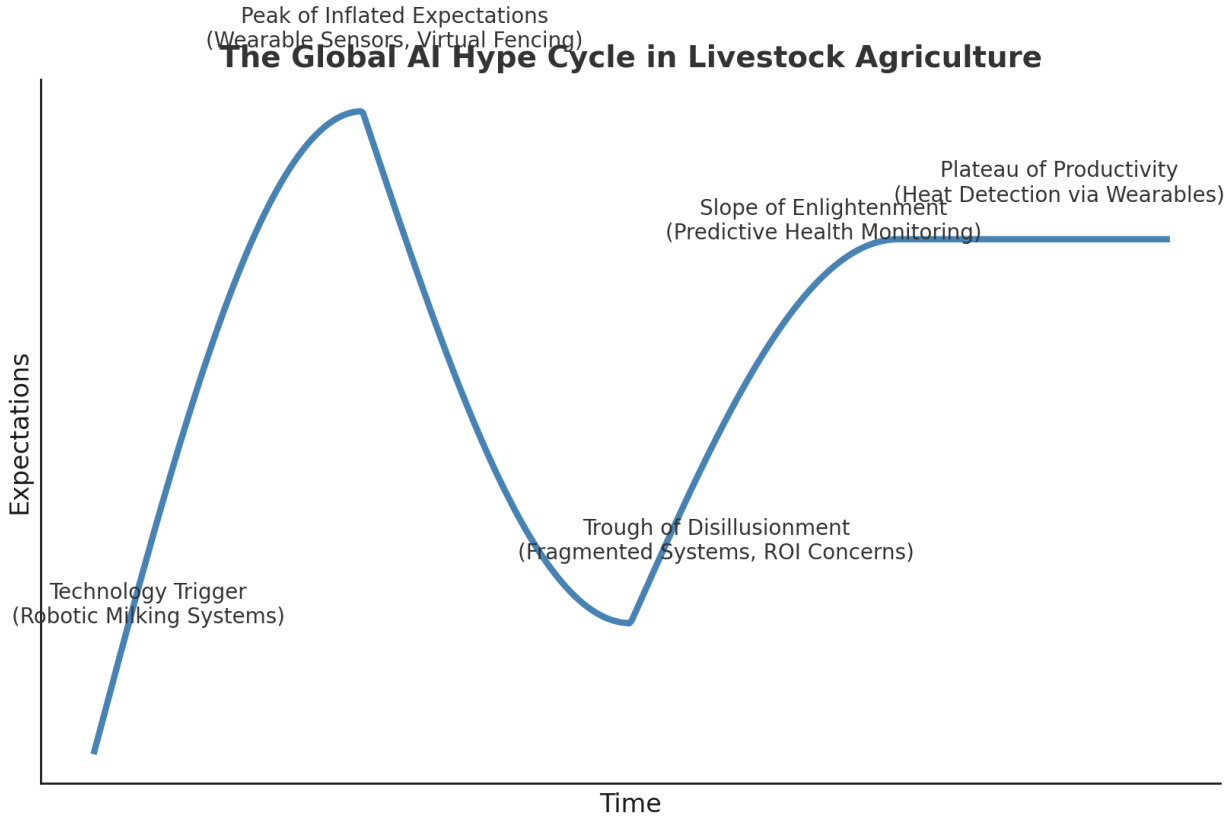
At the SVG Ventures Innovation Summit I attended in Silicon Valley, I had several conversations with industry leaders I deeply respect, many of whom are wiser and more experienced than I am; this skepticism kept surfacing. It wasn't coming from critics of technology, but from people who believe in its potential and have spent decades trying to make it work on real farms.

Many so-called AI systems are little more than rule-based algorithms or static models. Useful? Absolutely. But they lack the learning capacity and adaptive intelligence we see in industries like healthcare or autonomous vehicles.

This distinction matters because overhyping basic tech as “AI” erodes trust and slows adoption. Farmers burned by tools that overpromised and underdelivered often become cautious, even cynical.

But these first-generation systems weren’t a waste but rather they were a foundation. They helped farmers build confidence in digital feedback loops and created muscle memory for data-informed decision-making.

The next wave of tools, true AI, must build on that foundation while being transparent about how their models are trained, what data they use, and how they improve over time.



6. The Livestock AI Readiness Index (LARI)

Not every farm is ready to adopt artificial intelligence today. Readiness varies dramatically depending on factors like data quality, infrastructure, management practices, and even team culture.

This variability inspired the concept of the Livestock AI Readiness Index (LARI), a framework to help farmers, consultants, and policymakers assess their starting point and chart a path forward.

Below, I describe the beginnings of a quick evaluation that any farm can perform.

What Is LARI?

LARI is a diagnostic tool that evaluates farms across four key pillars:

1. **Data Maturity**
    a. Are data streams (health, feeding, reproduction) already being collected?
    b. Is the data labeled accurately, complete, and stored in accessible formats?
2. **Integration Readiness**
    a. Are current systems connected or siloed?
    b. Can existing hardware and software support AI integration?
3. **Team Capacity and Culture**
    a. Does the farm team have digital literacy and openness to data-driven decision-making?
    b. Is there a willingness to adapt workflows and trust AI recommendations?
4. **Infrastructure and Connectivity**
    a. Are broadband speeds sufficient for cloud-based systems?
    b. Are sensor and hardware upgrades needed?

The LARI Scale

Each pillar is scored on a 5-level scale:

Level	Description	Example
1	**Unprepared**	No digital records, no connectivity
2	**Emerging**	Basic sensors installed, limited data use
3	**Developing**	Data collected but systems are fragmented
4	**Ready**	Integrated systems, team trained, reliable connectivity
5	**Optimized**	Fully AI-integrated farm with decision-support tools

The goal isn't to rank farms against each other but to provide a roadmap for progress.

Why LARI Matters

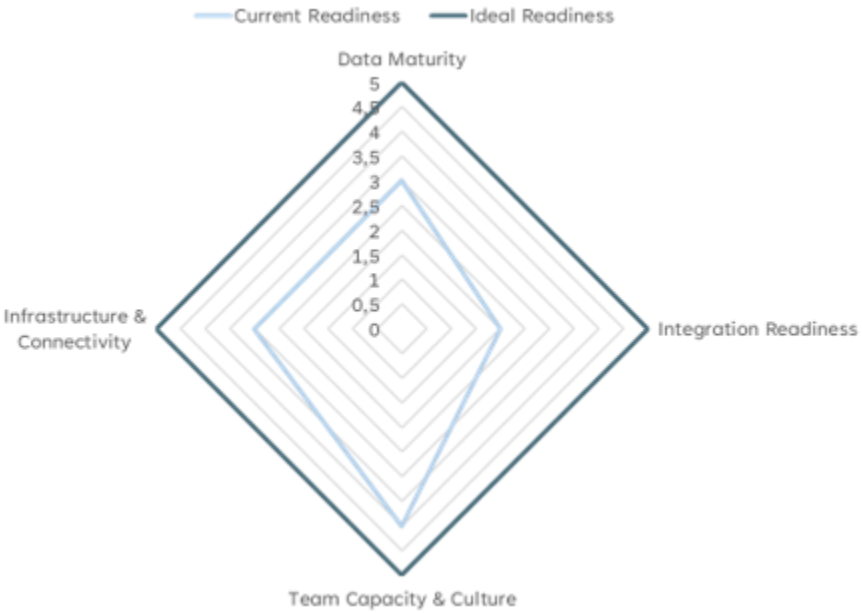
The Livestock AI Readiness Index, or LARI, is a bridge between data, practice, and policy. For farmers, it becomes a mirror that reveals where the gaps truly are, helping them see whether the next dollar should go into a new sensor, staff training, or infrastructure upgrades. For consultants, it provides a common language, a way to cut through the noise of competing technologies and give clear, actionable guidance on where AI adoption will pay off. And for policymakers, LARI highlights the uneven ground across regions; showing not just where the barriers to adoption exist, but how support programs can be better targeted to ensure no farmer is left behind. In that sense, LARI is more than a diagnostic tool; it's a compass that can guide investment, advice, and policy toward a shared future where AI in livestock delivers real, measurable value at every level of the system.

LARI in Action

Imagine two farms:

- Farm A collects data with activity monitors but still relies heavily on spreadsheets and manual observations. LARI score: 2.5 (Emerging).
- Farm B has integrated health, feeding, and reproduction data into a single platform, with a trained team actively using AI insights. LARI score: 4.2 (Ready).

Both farms can use their LARI profiles to focus on the next steps; whether it's investing in infrastructure, cleaning up data streams, or training staff.



7. Tech Evolution: From Startups to Giants

Artificial intelligence in livestock didn't begin with global corporations. It began with bold startups solving highly specific problems: detecting heat cycles, monitoring feed efficiency, scoring cow behavior. These early innovators pushed the boundaries of what was possible, one niche at a time.

But the industry is shifting. We're moving from fragmented point solutions to integrated platforms, and major players are consolidating control.

The Startup Phase: Solving One Problem Well

In the early days of agtech, most companies focused on doing one thing better:

- Detecting heat events with wearable sensors.
- Monitoring milk flow with robotic systems.
- Tracking activity with pedometers or cameras.

These tools delivered value but in isolation. They required farmers to interpret the data manually and often didn't connect to other systems. Contextual intelligence was missing because no tool understood the whole picture of the farm.

The Platform Phase: Integration is the New Advantage

Today, the landscape is changing. Leading companies aren't just selling tools; they're building platforms that unify data streams across: Health, reproduction, nutrition, and environment.

An example of this is GEA's acquisition of CattleEye, which is a targeted "single-solution" tool in vision AI. By plugging CattleEye's AI-powered lameness monitoring into a broader platform, GEA can now combine vision data with milk production, cow condition, and behavior trends, offering insights far beyond any one dataset.

This trend, platform companies absorbing niche innovators, will accelerate. Why? Because the real value of AI lies not in isolated alerts but in compound insights that emerge when multiple data streams converge.

Crossing the Holistic Insight Threshold (HIT)

This tipping point is what I call the Holistic Insight Threshold:

The moment where AI shifts from adding value to transforming strategy.

A platform that knows your feed inventory, cow genetics, forage and milk quality, and parlor performance can:

- Simulate future scenarios.
- Align decisions with business goals.
- Prioritize trade-offs across the entire system.

Farms that cross this threshold will pull away from the pack; not because they have better hardware, but because they have better system awareness.

Farmer Frustration is Driving Consolidation

Farmers don't want five dashboards. They want one system that works. As frustration grows with disconnected tech, the market will reward companies that consolidate data streams and simplify the user experience.

Soon, point solutions that don't integrate will be obsolete, no matter how well they solve a single problem.

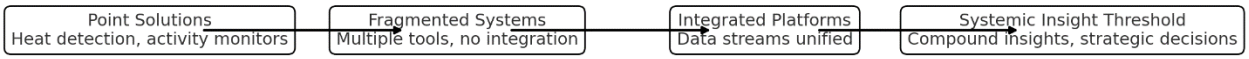
The Tension: Interoperability vs Farmer Freedom

But with consolidation comes a new tension: interoperability versus independence. Farmers want their tools and systems to work together seamlessly, but they don't want to surrender choice in the process. The danger is that whichever company first succeeds in unifying dashboards and data streams could leverage that position to dominate the market, forcing producers into closed ecosystems. This kind of lock-in erodes the very flexibility farmers depend on to choose the genetics, feed systems, or management tools that fit their unique operation.

True progress will come not from monopolization, but from open standards and permissioned data flows that allow multiple providers to plug into the same backbone. Farmers don't want five dashboards, but they also don't want a single company

controlling the future of digital agriculture. The challenge for the industry is to deliver the simplicity of consolidation without sacrificing the freedom of choice that keeps innovation and trust alive.

Tech Evolution in Livestock AI: From Startups to Giants



8. Autonomous Labeling: A Paradigm Shift in Data Quality

As artificial intelligence systems in livestock farming mature, one of the most transformative developments will be the shift from human-labeled datasets to autonomous labeling by the AI itself.

At present, much of the data used to train livestock AI, whether for health monitoring, feeding, reproduction, or environmental management; relies on farmers, veterinarians, or consultants manually entering events and outcomes. This process is often inconsistent, incomplete, and subject to human error or bias, leading to what I called earlier, “dodgy data.”

In the future, however, well-trained AI models will increasingly be able to identify and label events on their own. For example, rather than relying on a farmer to tag a cow as having mastitis, the AI could learn to recognize subtle, multi-sensor patterns; such as changes in activity, temperature, milk conductivity, and behavior, that correlate strongly with the onset of disease. This transition to autonomous labeling would result in cleaner, more consistent datasets, enabling more accurate analysis and better decision-making at the herd level.

A Tesla Analogy: Self-Improving Systems

A useful analogy comes from Tesla’s approach to self-driving cars. Initially, Tesla engineers manually labeled massive volumes of video footage to teach the system how to recognize stop signs, pedestrians, and lane markings.

As the company’s footprint in the market expanded, Tesla began leveraging real-world driving data to train its AI to identify and label these elements automatically. Elon Musk described this breakthrough:

“Essentially, the driver when driving and taking action is effectively labeling, labeling reality, as they drive and [make] them better and better. I think this is an advantage no one else has, and we’re quite literally orders of magnitude more than everyone else combined.” (Musk, 2020)

Just as Tesla’s cars became distributed data collectors that continually refine the AI’s understanding of the road, livestock farms equipped with sensors, cameras, and

monitoring devices could function as distributed data collection networks. AI would process these streams to identify and label events such as heat cycles, sub-optimal feeding behavior, or environmental stressors without requiring human intervention.

Implications for Livestock Systems

This shift has profound implications. By reducing the labor burden of manual data entry, farmers and their teams are freed to focus on decision-making rather than clerical work. It also minimizes the human subjectivity that often creeps into scoring and labeling, creating cleaner, more reliable datasets. Perhaps most importantly, it enhances the system's ability to detect complex, multi-factor patterns that would otherwise go unnoticed by the human eye. Together, these changes lay the groundwork for crossing the Holistic Insight Threshold, the tipping point where AI insights begin to compound rapidly, no longer constrained by the limitations of poor-quality input data.

While challenges remain around validation, trust, and explainability, autonomous labeling represents a key milestone in the evolution of AI. It holds the potential to fundamentally change how farmers manage their animals and operations.

9. Global Use Cases of AI in Livestock

To understand AI's real-world impact, we need to look beyond headlines and into barns, paddocks, and data centers around the world. Here are just five examples from my Nuffield travels that illustrate how AI is reshaping livestock management in practical, often unexpected ways.

USA, Texas – AI Eyes in the Parlor

On a dairy in Texas, I saw CattleCare's computer vision system monitoring milking protocols in real time. The software tracked:

- Cow handling practices
- Time spent prepping each animal
- Consistency of routines

Each employee received a performance score based on adherence to best practices. Bonuses were tied to these scores, incentivizing better animal handling and protocol compliance.

What stood out wasn't just the technology, but how it transformed human behavior. By turning subjective tasks into measurable standards, AI aligned the entire team around animal welfare and efficiency.

New Zealand – Halter's Virtual Fencing as an Intelligence Layer

In New Zealand, Halter's virtual fencing system impressed me not just as a labor-saving tool, but as a strategic innovation. Using GPS collars, real-time behavior tracking, and predictive algorithms, it enabled farmers to manage livestock without traditional fencing.

But its real power lay in its intelligence layer:

- Predicting cow movement
- Suggesting optimal grazing break sizes
- Integrating pasture growth models

Farmers were rethinking crop rotations, waterway protection, and even stocking densities based on insights from Halter's platform. This wasn't just about removing fences; it was about redesigning grazing systems entirely.

Both pictures are from my visit to Halter HQ in Auckland, NZ.

Israel – Predictive Feed Intervention with AlphaBiome.ai

AlphaBiome.ai is pioneering an AI-driven approach to feeding by analyzing rumen microbiome DNA and extensive herd data. Its algorithms predict which feed interventions, like specific additives, will be most effective for each herd.

This microbiome-guided, herd-specific strategy exemplifies how AI can optimize nutrition, enhance efficiency, and reduce environmental impact without relying on one-size-fits-all solutions.

Taking samples of cow's rumen fluid for analysis.

Sweden – Platform Integration

At the global headquarters of a leading dairy equipment manufacturer, Delaval, I saw the future unfolding. They were not just building milking equipment; they were creating platforms. By integrating data streams from milking, feeding, movement, and behavior, their systems applied machine learning to predict outcomes and guide decisions, not only for farmers but also across their global dealer network.

Delaval world HQ in Tumba, Sweden.

Australia – Drone Mustering in Extensive Grazing Systems

In Australia, SkyKelpie has developed AI-powered drones for cattle mustering. Their systems use:

- Image recognition to detect and track herds
- Autonomous flight algorithms to influence animal movement
- Virtual training environments (SkySim) to prepare stock managers for real-world operations

SkyKelpie's drones have reduced reliance on helicopters and motorbikes while improving animal welfare and safety. This innovation shows how AI can thrive even in rugged, extensive grazing systems.

Cow calf herd grazing in New South Wales, AU

USA, Arizona – Lessons from Autonomous Vehicles

Though outside of agriculture, my ride in a Waymo autonomous taxi in Phoenix left a lasting impression. The car navigated traffic using predictive modeling, computer vision, and sensor fusion, not just reacting to obstacles but anticipating them.

This is where AI in livestock needs to go: beyond reacting to heat events or health drops, toward learning patterns, simulating scenarios, and guiding proactive management of complex ecosystems.

Waymo taxi in Phoenix, AZ

Key Takeaways from the Field

These examples share a common thread: AI is most impactful when it doesn't just automate tasks but reshapes strategy and management. Whether it's virtual fencing in New Zealand or computer vision in Texas, AI succeeds when it integrates seamlessly into farm systems and empowers people to make better decisions.

10. Roadblocks: Why AI Isn't Winning (Yet)

For all its promise, artificial intelligence in livestock is not yet living up to its full potential. During my travels, I repeatedly heard variations of the same story: farmers invest in new tools, only to find themselves frustrated, overwhelmed, or underwhelmed.

Here are the key barriers holding back widespread AI adoption:

1. Dodgy Data

AI systems are only as good as the data they learn from. In livestock systems, data is often:

- Incomplete: Key events like calvings or health interventions go unrecorded.
- Inconsistent: Different workers log information in different ways.
- Biased: Human inputs reflect subjective judgments.

This "dodgy data" undermines trust in AI recommendations and limits the accuracy of predictions. Autonomous labeling (discussed in Step 6) offers hope for cleaner datasets in the future, but for now, poor input quality is a stubborn bottleneck.

2. Fragmented Systems

Many farms are stuck with a patchwork of technologies; one system for reproduction, another for feeding, and a separate one for health alerts.

These tools rarely "talk" to each other. The result is that farmers are left with multiple dashboards and no single source of insight. Integration is still the exception, not the rule.

3. Culture and Human Behavior

AI is as much a people problem as it is a technology problem. On many farms, resistance to change is real, often summed up in the familiar phrase, *"We've always done it this way."* Experienced farmers, with years of intuition, can be hesitant to trust

algorithms over their gut instincts. At the same time, employees may push back, feeling that AI systems are more about monitoring and micromanagement than support. These dynamics reveal a simple truth: even the most advanced AI tool will fail if the farm team isn't trained, motivated, and truly bought into using it.

4. Lack of Infrastructure

In some regions, limited broadband connectivity and aging hardware make AI adoption difficult. Cloud-based systems can't deliver insights in real time if internet speeds and band-width lag behind.

5. Trust and Explainability

Farmers want to understand *why* an AI recommends a certain action. Black-box algorithms that can't explain their reasoning create skepticism and slow adoption.

6. Economic Barriers

Upfront costs remain high for many AI tools. Without clear ROI evidence, farmers are understandably hesitant to invest, especially in regions where margins are thin.

7. Regulatory Lag

Technology moves fast. Policy doesn't. Whether it's virtual fencing, data ownership, or new surveillance tools, many governments haven't updated their frameworks to account for modern AI tools. This creates risk and uncertainty for innovators.

An example that I saw first-hand in the state of Victoria in Australia was the banning of virtual fencing technology. I believe this was due to a lack of understanding and unwarranted hostility towards this new technology. Since my visit to Australia in February of 2025 it is my understanding that this ban has now been lifted because of the evidence for the good the technology can provide to farms that adopt it.

We need regulators who understand AI and are willing to create sandboxes for safe experimentation, not frameworks that punish early adopters. This was hit home by USA Vice president J.D. Vance in his speech at the AI Action Summit in Paris in February of 2025. In his address, Vance cautioned against "excessive regulation" of AI, arguing that such measures could hinder innovation and economic growth. He emphasized the importance of fostering an environment that encourages technological advancement, warning that overregulation might stifle the transformative potential of AI technologies.

The Common Thread: Integration and Trust

These roadblocks reveal a deeper truth: AI can fail, not because the algorithms aren’t smart enough, but because the systems around the technology; data flows, infrastructure, human behavior, and policy aren’t ready to support it.

Overcoming these barriers requires more than technical fixes. It demands collaboration between farmers, technologists, and policymakers to create an ecosystem where AI can thrive.

11. Global Map of Adoption Readiness

Artificial intelligence is not diffusing evenly across the livestock world. On my Nuffield travels, it became clear that adoption is shaped by more than the technology itself. Culture, economics, policy, infrastructure, and farmer trust all determine whether AI is embraced as a strategic partner or held at arm's length. What emerged for me was a three-tiered landscape: pioneers, experimenters, and watchers, each defined less by the tools they had, and more by how they chose to use them.

1. High-Readiness Regions: Pioneers

Nowhere did I see a more confident embrace of AI than in Western Europe, particularly the Netherlands and Denmark. Here, adoption is not just about installing new tools but about weaving them into a broader ecosystem. Robust rural broadband and sensor infrastructure are baseline expectations, not luxuries. Universities, agribusinesses, and government agencies are deeply involved in driving adoption, ensuring that farmers aren't left to piece together solutions on their own. Most striking was the cultural attitude: Dutch and Danish farmers treated AI not as a threat to their instincts but as an extension of them. On one Dutch dairy I visited, the conversation was less about whether to use AI, and more about how to refine it for herd-specific challenges. That openness coupled with institutional support is why Western Europe is already setting the pace for livestock AI.

2. Mid-Readiness Regions: Experimenters

By contrast, countries like the United States, Canada, Australia, and New Zealand have the scale, capital, and entrepreneurial ecosystems to lead — but adoption is uneven and often fragmented. In Australia, I encountered a striking divergence: highly intensive, high-input farms that leaned into data-driven efficiency, versus low-input, low-yield operations that saw little incentive to invest. Policy has also played an outsized role. During my visit, I saw how Victoria's temporary ban on virtual fencing stalled momentum, not because the technology wasn't effective, but because regulatory misunderstanding got in the way of progress. Across North America and New Zealand, robotic milkers, sensors, and collars were widely deployed, but integration was sorely lacking. Farmers often told me they had "five dashboards and no single source of truth." Trust was also an issue. Unlike the confidence I saw in Western Europe, many farmers here viewed AI outputs with skepticism, preferring their own judgment until proven otherwise. These regions are experimenting but without integration, policy clarity, and cultural trust, they remain stuck in the middle tier.

3. Low-Readiness Regions: Watchers

In conversations with people working in Africa, Southeast Asia, and parts of Eastern Europe, a different picture emerged. Here, the obstacles were more fundamental: unreliable internet and even electricity, thin farm margins, and a lack of technical expertise. Pilot projects in dairy management often began with promise but failed to scale because the infrastructure simply wasn't there to support them. A development worker I spoke with in Kenya explained that even when health apps were introduced, maintaining connectivity and training staff was a large barrier. For these regions, AI adoption remains more aspiration than reality, not because the need is absent, but because the enabling environment has yet to catch up.

What these three tiers made clear is that readiness is not just about tools. It is about ecosystems. Western Europe is sprinting ahead because institutions, culture, and infrastructure align. The U.S., Canada, New Zealand and Australia are strong experimenters but remain hampered by fragmentation and trust gaps. And in much of the Global South, the challenge is not convincing farmers of AI's value, but building the basic foundations that make adoption possible. AI's global spread, in other words, is uneven by design, and the farms that thrive will be the ones whose ecosystems help them cross from experimentation into confidence.

12. Vision: The AI-Integrated Livestock Farm of 2035

It’s 2035. The family livestock farm is still here, but it’s not the same.

On this farm, data isn’t something that has to be collected, it flows automatically through every system. The farm has an AI-powered tech stack, with layers of hardware, software, and algorithms working together like an invisible nervous system. Sensors, cameras, and predictive models don’t just monitor; they anticipate, simulate, and guide decisions across the entire operation.

This isn’t about a single tool or dashboard. It’s about whole-system intelligence.

Morning on the Farm

As dawn breaks, the farmer doesn’t start the day with a walk through the herd or a check of the parlor. Instead, they open the farm’s AI Command Center on their tablet or phone, a concise “Morning Briefing” generated in seconds.

It highlights:

- Health alerts: Two cows showing early signs of ketosis, detected through patterns in rumination, feed intake, and milk conductivity. It will suggest the most effective treatment plans for the herdsman to administer.
- Breeding recommendations: A prioritized list of cows ready for insemination, based on genetic merit, production history, feed efficiency; calculating a financial profit prediction.
- Pasture moves: A grazing plan optimized by the AI to balance forage regrowth, soil health, and herd movement behavior.
- OR: Feed adjustments: tweaking the diet our amount of feed mixed for each pen of cows based on the expected weather for the next 24 hours.
- Labor management: Task assignments for staff, adjusted for skill levels and workload balancing.
- Digital Farm Twin: Running a scenario to look at the financial impact across every aspect of the farm of moving your calving interval 10 days out.

Decisions that used to take hours of observation and analysis now take minutes, with clarity and confidence.

A Tech Stack That Works Together

The modern farm technology stack is a far cry from the fragmented systems of the past. Today, hardware such as robotic milkers, GPS collars, drones, cameras and automated feeders integrates seamlessly with networks of sensors that monitor everything from rumen pH and cow activity levels to temperature and environmental conditions. All of this streams into an intelligent software platform that synchronizes data across health, reproduction, feeding, and labor. Instead of toggling between apps or cross-referencing endless spreadsheets, the farmer interacts with a unified system that functions more like a single, intelligent organism, one that works alongside them to manage complexity and reveal insights no siloed tool could provide.

The Decision Layer: From Data to Strategy

This farm has crossed the Holistic Insight Threshold. Instead of making decisions in silos; one for feeding, another for breeding, another for labor, the AI now evaluates trade-offs across the entire system. It can answer practical, forward-looking questions that were once impossible to calculate in real time: What happens to milk production if I extend grazing by two weeks? How will adjusting calving intervals affect cash flow ten months from now? What's the optimal balance between heifer retention and culling given current forage availability? In this model, the farmer doesn't lose control of their operation. Instead, they gain a strategic partner; a system that can think across time horizons and operational layers, surfacing insights that strengthen the farmer's own decision-making.

The Human Element

The farm is more autonomous, but not human-less. With intuitive interfaces and AI-assisted training tools, even less-experienced staff can work effectively from day one.

The farmer isn't buried in tasks. They're free to focus on relationships, strategy, and stewardship; returning to the role of conductor rather than firefighter.

13. What It Takes to Get There

Building the AI-powered livestock farm of 2035 isn't about waiting for a technological miracle. The challenge lies in aligning people, systems, and incentives to make them work together.

Here's what it will take to get there:

1. Integrated Systems, Not Fragmented Tools

The era of single-point solutions must end. Farmers don't need another dashboard; they need unified platforms where health, reproduction, feeding, and labor systems speak to each other.

Action: Encourage tech companies to open APIs, embrace interoperability, and design farmer-centric ecosystems. Platforms that force farmers into walled gardens will not win.

2. A Data Stewardship Revolution

Farmers must own and control their data. Without trust in how data is handled, adoption will stall.

Action: Create cooperative models and governance structures that ensure farmers remain stewards of their information while still benefiting from aggregated insights.

3. Building a Skilled Workforce

AI doesn't eliminate people; it changes the skills they need. Future farm teams will blend animal husbandry knowledge with digital literacy.

Action: Invest in training programs that prepare workers to collaborate with AI systems. The best farms will be those where technology amplifies human potential, not replaces it.

4. Clear ROI Pathways

AI adoption rises and falls on economics. If farmers can't see clear financial benefits, they won't invest.

Action: Focus on tools that deliver measurable returns, whether through reduced feed costs, improved reproduction rates, or labor efficiencies. Showcase early adopters with real-world results to build momentum.

5. Infrastructure to Support Innovation

Without reliable broadband, cloud-based AI systems are useless. And without hardware capable of supporting AI's demands, farms will be left behind.

Action: Expand rural connectivity and ensure affordable access to next-generation devices and sensors.

6. Culture Change in Agriculture

People are most often resistant to change, especially when they are suspicious of it. In agriculture, this makes adopting AI as much a cultural challenge as a technical one. Trust in data, openness to experimentation, and a willingness to learn new systems are what separate early adopters from those left behind. Culture doesn't shift overnight, but small, visible wins help build confidence.

Action: Share stories with your team, of farmers who've successfully integrated AI to inspire peers and normalize adoption.

The Bottom Line

AI in livestock farming isn't about replacing the farmer or their team. It's about unlocking their ability to steward animals and land with greater precision and confidence.

The future belongs to those who prepare today; not just with tools, but with the systems, skills, and mindset to use them well.

14. AI Stewardship Cooperatives: Farmers Owning the Future

If data is the fuel for artificial intelligence, then farmers must be the ones holding the keys to the fuel tank.

Today, much of the data generated on farms flows outwards to equipment manufacturers, software providers, consultants, and industry bodies. Too often, it leaves the farm with little transparency or control. The value of that data is being captured elsewhere, while farmers are treated as passive “data providers” rather than active participants.

As AI systems mature, this imbalance will only deepen unless a new model emerges, one that gives farmers collective power over the digital assets they create every day.

This is where AI Stewardship Cooperatives come in.

Reimagining the Cooperative Model for the Digital Era

Agricultural cooperatives have long been part of farming life. They began with shared milk trucks, grain elevators, and marketing boards; physical infrastructure built to give small farms leverage in a world of growing corporate power.

An AI Stewardship Cooperative is a natural evolution of this idea. But instead of pooling milk or feed, farmers pool data, insights, and influence in the AI ecosystem.

It would:

- Aggregate and standardize data across member farms to train robust, unbiased AI models. A larger data pool is a more powerful data pool.
- Guarantee data ownership stays with farmers, ensuring they control access and permissions.
- Negotiate equitable partnerships with tech firms, researchers, and policymakers.
- Distribute financial rewards back to farmers when anonymized, aggregated data generates value.
- Give the ability to create powerful benchmarking tools for farmers.

This isn't about resisting innovation. It's about ensuring farmers are co-creators of the AI tools shaping their future, not just passive consumers.

Why We Need AI Stewardship Cooperatives

1. **Trust and Control**
   Farmers are rightfully cautious about sharing data. Stories of platforms "locking in" users, or companies using farm-level insights to gain competitive advantages, have created a culture of distrust. A cooperative flips that dynamic, giving farmers collective oversight over how their data is used.

2. **Scale for Better AI**
   AI thrives on scale. A single farm's data is valuable; thousands of farms' data is transformative. By aggregating datasets while protecting individual privacy, cooperatives create the critical mass needed to train systems that work for diverse farm contexts, not just the largest operations.

3. **Leverage in the Market**
   As AI becomes embedded in feed decisions, health protocols, and even pricing models, farmers need bargaining power to ensure tools are designed around their realities, not just corporate profit motives. Cooperatives give them a seat at the table.

4. **Shared Value Creation**
   Why should all the financial upside of AI flow to technology firms? Farmers are the ones creating the raw material, data, and they should share in the value it generates beyond the farmgate.

How It Might Work

Imagine this: a regional or sector-specific AI Stewardship Cooperative forms, uniting dairy farms under a shared mission of data ownership and collective intelligence. Each farm agrees to contribute anonymized data streams—milk yields, health records, sensor outputs, and other performance indicators—through secure, standardized protocols.

To support its members, the cooperative employs technical specialists who help farmers clean, standardize, and optimize their data streams, ensuring every contributor

maximizes the value their information can generate. With these high-quality datasets in place, the cooperative negotiates partnerships with AI companies to develop decision-support platforms tailored specifically to member needs, rather than generic industry models.

The AI systems are then trained on this aggregated dataset, producing insights and tools that are far more accurate and contextually relevant than anything built from fragmented or global data alone. As the cooperative licenses anonymized, aggregated insights to researchers and industry partners, the resulting revenues flow back to its members, funding patronage dividends, on-farm innovation, and training programs that equip farmers to lead in the era of intelligent agriculture.

The Bigger Picture: Reshaping Power Dynamics

AI Stewardship Cooperatives could redefine the relationship between farmers and the tech ecosystem. Instead of data flowing up the supply chain to be monetized by others, value would stay rooted in the communities that produce it.

This model also creates opportunities for cross-sector partnerships. Imagine cooperatives collaborating with universities, NGOs, and governments to tackle challenges like antimicrobial resistance or workforce shortages, using aggregated insights to design better policies and tools.

From Physical Assets to Digital Ones

Farmers are used to thinking about tractors, barns, and land as assets. In the AI era, data is the asset. And just like a herd or a field, it needs to be stewarded wisely.

The question is no longer whether AI will shape livestock farming. It’s who will own the future it creates.

If farmers don’t organize to own their data collectively, someone else will.

A Global Vision for AI Stewardship Cooperatives

Now imagine this idea scaling beyond a region or country:

- A network of AI Stewardship Cooperatives across continents, exchanging anonymized insights to strengthen AI models globally.

- A farmer in New Zealand benefits from disease detection algorithms refined with datasets from Ireland, Israel, and Wisconsin, without ever sacrificing privacy or ownership.
- These global networks could set standards for fair data governance in agriculture, counterbalancing the dominance of corporate giants.

This isn’t just a vision for smarter farms. It’s a vision for a fairer, more farmer-centered agricultural future in the digital age.

15. Conclusion: A Call to Action

Artificial intelligence is no longer a futuristic idea in livestock farming; it is here, and it is progressing rapidly. The question is not whether AI will shape the future of agriculture, but who will own that future and how it will be shaped.

Throughout this journey, I have seen both the potential and the pitfalls. I've visited farms where AI systems are quietly transforming animal care and labor efficiency, and I've spoken with farmers who feel overwhelmed and skeptical about technology's role in their operations.

What's clear is this: Success with AI in agriculture will depend on the systems, culture, and leadership we build around it.

Three Priorities for the Future

1. **Empower Farmers as Stewards of Data**
   Farmers must own and control the digital assets their farms generate. Without this, the promise of AI risks being captured by others.
2. **Build Systems That Work Together**
   Interoperability is non-negotiable. Fragmented tools must give way to integrated platforms that help farmers see and manage the whole system.
3. **Focus on People, Not Just Technology**
   AI should not replace people. It should empower them to make better decisions, create healthier farms, and steward their animals and land with confidence.

The Opportunity in Our Hands

We stand at an inflection point. The choices we make now will determine whether AI deepens the disconnect between farms and technology or whether it becomes a tool that strengthens rural communities, gives confidence in decision-making, and creates more resilient livestock systems.

The future of agriculture is something to be built now; the best way to predict that future is to create it.

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