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Hi-Tech Humanitarianism: tech adoption on farm

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Executive summary

Adoption of digital technology on farm has been largely for business as usual activities that are a “nice to have” aspect rather than a “must have”. In the future agribusinesses will use digital technology to lower operating costs, increase productivity and expand to new markets or develop new product offerings.

The aim of this study is to discuss the six emerging technologies and what this means for farmers. The technologies covered are Artificial Intelligence (AI), Virtual Reality (VR), Augmented Reality (AR), Internet of things (IoT), Blockchain and Quantum computing. The underlying principles, for how they the technologies work and practical applications in the field of agriculture.

It is my opinion that to maintain a competitive advantage in the wake of Agriculture 2.0 technology, which focuses on automation of tasks for efficiency and productivity, the discussion needs to be much larger than what gadgets have come out and how they will improve our productivity. Digital technology is table stakes. While technology is no substitute for the human element, when used strategically and appropriately, it helps overcome hurdles and brings farmers and consumers together for the greater good of both.

My analysis of the literature and in my experience working on New Zealand farms has shown that a deliberate, conscious decision to use technology has to be made from the top down. New skills and attributes must be developed. These include: creativity, agility and adaptability, critical thinking and problem solving. Important conclusions from this study are that farmers should be:

- Having the right learning environment and a positive attitude towards technology.
- Learning from other sectors and nations that have adopted and implemented technology successfully and applying learnings.

- Proactively involved in coming up with solutions to their own problems and working alongside solution providers to refine these solutions.
- Lifting the profile of on farm innovation for the greater good and industry wide application.
- Embracing diversity of thought and exploring new ways of doing things on farm all the way along the supply chain. As business models, economics, and skill requirements shift, we could well see major changes in top positions, at both the company and regional levels.

1 Introduction

Global digital adoption rates place New Zealand 21st for individual adoption rates with 70 % of the population owning a smartphone. Reflecting on the lifecycle of the market approximately two thirds of all adult New Zealanders now have access to three or four devices (Deloitte, 2015).

AIM

The aim of this study is to uncover ways emerging digital technologies can be applied to smart and sustainable farming. Technology has made its way into our lives and now to our businesses. Technology has the potential of having a real impact on farms now and in the future. Why it is important to take the long view and how farmers might keep up to speed and innovate along with or ahead of the global sustainable farming ecosystem.

I had set out to find the factors affecting farmer adoption of digital, biological and physical technologies on New Zealand farms. I was also interested in studying the ecosystem underpinning innovation in agriculture, with a vested interest in digital technology as an entrepreneur and service provider.

Agricultural production systems are complex and multifaceted. The solutions require knowledge ranging from broad to specific. Thus, an important part of the study is evaluating the attitudes towards GMO's, gene editing and most recently genome editing all clustered under the topic of emerging technologies. When I came to the realization that the project would have been a gargantuan task, the scope of which I would not be able to cover under this programme of study, I narrowed my focus down to emerging digital technologies and implications for the future of farming.

Change is happening at an unprecedented rate. Technology goes beyond mere tool making: it is a process of creating ever more powerful technology using tools from the previous round of innovation (Kurzweil, 2006).

For farmers to maintain a competitive advantage in an increasingly protectionist world, technology plays a critical role in evening out the field of play. How farmers embracing emerging technologies impacts how they a competitive edge.

The fundamentals to the adoption of technology and change require farmers to be proactively involved in coming up with technological solutions to their problems (Hockin M, 2017), as this has become significantly less costly and out of reach unlike in years past.

The Netherlands has become an agricultural giant by showing what the future of farming could look like. An agricultural revolution is underway as technology connects producers to crops, animals and machinery like never before. The farming community has always been innovative. By necessity, an industry that dates back thousands of years has required constant adaptation to survive. Technologists believe disruptive change will impact the industry at an unprecedented rate, fundamentally and substantially changing business practices and models.

New ways of connecting, transacting and delivery of business models and decision-making abilities will be required. All new technologies are first, and foremost tools made by people for people. Technological transformation requires new business models which encourage collaboration and traceability, efficiency, rapid escalation and resolution and higher productivity.

1.1 Background

I have developed Tribal, an Occupational Health and Safety virtual assistant mobile-first software for managing occupational risk on farm. In this role as a founder of a technology business providing health and safety software to an agricultural market has given me a unique insight into the accompanying barriers to tech adoption on farm.

Technology offers a unique opportunity for New Zealand agriculture to maintain a competitive advantage by developing novel agribusiness models. Like the Netherlands with indoor farming that has reduced the need for chemicals by 70% and increased their potato yield by 202 % though adopting sensors, IoT and digital technology (Viviano, 2017).

The way farm work is done is about to change dramatically along with the exchange of data along the supply chain. The world collectively is at the cusp of the 4th industrial revolution (Schwab, 2016).

1.2 The research

Effort directed at research and development is evidence through initiatives by the Crown Research Institute, Ag research and links to local universities. There is however, a disconnect between the resource going into R&D activities and the adoption of the technologies by the intended end user. This has been due to not having enough people with the right skills and capability to support adoption of emerging technologies and therefore to compete successfully internationally (MBIE, 2016).

Fresh perspectives will be introduced to the industry may result in process innovation, increased knowledge and capacity to innovate on the system as a whole. Technology consultants specifically for agriculture and training offered for these vocations at tertiary institutions.

Farmers often perceive that technological change will be incremental, manageable, and supportive of the status quo (Kelly, 2017). These new sources of data create the opportunity to inform and drive a change in decision making from one that is highly intuitive to one that is data driven and processed in real-time. It is my opinion that smart farming will dramatically change the old way of doing things and replace business models, economics, and skill requirements, we could well see major changes in agribusiness.

2 Methodology

This study drew on three processes: lit review, interviews and an examination of a case study.

Through my literature review, I accessed reports from extensive searches on Google Scholar, journals and online publications in the technology and agriculture space. I used sources that were from the last ten years given the rapid technological advances. The review shows that the applications of smart farming goes beyond primary production; it is influencing the entire supply chain.

In reviewing the literature attention was paid to both technical and socio-economic aspects. Due to the rapid rate of change in technology, the analysis primarily focuses on the socio-economic impact smart farming will have on farmers and agribusinesses and the whole ecosystem around it.

The research questions to be addressed were

1. What stakeholders are involved and how are they organized?
2. What expected changes are caused by emerging technologies
3. What challenges need to be addressed in relation to the previous questions.

I also went about interviewing Richard Wakelin the Innovation Manager for Beef and Lamb New Zealand, an industry good organization that had embarked on an aspirational future farms program as test bed for emerging technology. I also interviewed Mat Hockin who is a farmer and innovator and Nuffield scholar who has travelled globally to uncover the effects of technology on the future of farming.

3 Analysis

This Fourth Industrial Revolution is fundamentally different to past revolutions. It is characterized by a range of new technologies that are fusing the physical, digital and biological worlds, impacting all disciplines, economies and industries, and even challenging ideas about what it means to be human (Schwab, 2016).

Agriculture is no exception. The emergence of digital technologies Internet of Things (IoT), Virtual Reality (VR), Augmented Reality (AR), Blockchain and Quantum Computing will allow production to be 30% faster and 25% cheaper by removing current inefficiencies in the way data is transferred between systems.

The perspective that tomorrow will be recognisable, just with more technology, has the potential to be problematic. It is likely that technology will facilitate radical change to business models. Technology, has the potential to radically change the agri-food sector and, through intensity and integration, the competitive landscape (Kelly, 2017).

New Zealand's growing strengths in agriculture and technology presents an opportunity for smart farming, incorporating advanced management information systems, precision agriculture, and agricultural automation and robotics. Agritech will become the norm and a competitive necessity in all developed countries.

The greatest challenge to address lies in avoiding the temptation to believe that business as usual is the only possible solution. The idea that framers need to see how the proposed technology adds value to their current practices is inherently flawed. It is suggested farmers need to be taking a proactive approach in being involved with the development of solutions to their problems.

Anticipating the future and what adoption needs to be stemmed in the belief that there are benefits to applying this technology to the long-term strategy sector wide for the collective good.

3.1.1 Industry utilization adoption of technologies

For the New Zealand economy to continue to grow and do so sustainably within environmental limits, technology transfer will be increasingly important. Farms are becoming more complex and sophisticated. They are becoming larger and employing more staff and more technology.

Low adoption rates can also be attributed to the relevant participants in agri-food businesses not being involved (or not heavily involved) in the technology development. Despite the abundance of existing tools, farmers and farm consultants may simply not be aware of the range of tools at their disposal. Additionally, the available tools are disproportionately represented in the more well-established areas and underrepresented in newer areas of farm management (nutrients and labour), and there is a need for interconnectivity of tools for efficiency of operations (Allen & Wolfert, 2011).

3.1.2 On farm adoption – reasons for low adoption

Technology transfer is defined as the process of introducing new ideas, tools, processes and practices enabling change in individuals, communities and industries involved in the primary sector and with natural resource management. It is about giving people the confidence to try and ultimately succeed in doing things differently (MPI, 2012).

It encompasses those people who provide information and advice that supports individuals and firms to achieve their business objectives.

There remains limited widespread adoption of innovative technologies, and many of the existing tools focus on single or limited-range processes (Allen & Wolfert, 2011; Lehmann, Reiche, & Schiefer, 2012; Verdouw *et al*., 2014).

3.1.3 Global adoption rates and how NZ farmers compare

In the US, tools that optimize nitrogen dynamics need to consider soil, weather, and crop-related processes that all have interacting physical, biological, and chemical components. These in turn need to be considered in the context of a wide diversity of practices, production environments, and socioeconomic conditions on farms. Solutions are often more complex and less scalable than optimization processes in manufacturing industries or communications. This is arguably the primary reason why digital innovation in agriculture has been relatively slow and the leading global digital technology companies have made few inroads into agriculture (Van Es, Woodward ,2016).

The U.S. currently leads the world in IoT smart agriculture, as it produces 7,340 kgs of cereal (e.g. wheat, rice, maize, barley, etc.) per hectare (2.5 acres) of farmland, compared to the global average of 3,851 kgs of cereal per hectare. This efficiency should only improve in the next decade as farming becomes more connected (Meloa,2016).

4 Case study best practice Future Farms – tech adoption on farms

A key learning taken from RMPP (Red Meat Partnership Profit) research was in understanding farmer behavior and in particular, understanding the high performing farmers adopting emerging technologies. In the case of high performers, they only applied technology if it was going to make their business better, either through efficiency or increasing value. Often, they weren't "pioneers", but early adopters of proven technology. Learning how to apply the technology is critical if it is going to deliver on product/tool claims.

The last one, on farm support for adoption, is critical. Farmers are time poor and whilst technology-engaged farmers will always find extra time to apply themselves to new technology, expansion to the not-so-tech savvy will require additional support networks.

Focus of the future farms is towards the challenges of on farm adoption by farmers. As technology is likely to involve the purchase of some form of hardware/software, the role of rural retailers and suppliers is likely to increase in this space (e.g. Farmlands and Ballance are both involved in the Spark project in the Waikato).

It is almost in the "after sales" space where B+LNZ is identifying opportunities for extension activities. As in many cases the sales process will concentrate on the performance of the product and advantages of using it. However, B+LNZ may have a role as an "integrator or connector" in helping farmers understand how the new information, or output from the tool can be integrated into a whole farm system. The value of the technology will be realised when it performs within the whole farm system (Wakelin R: Pers Comm).

Extension activities aimed at farmers will help farmers gain an understanding of the benefits that come with interconnected platforms on the farm sharing data and optimization of output with minimal input through adoption of digital technology.

4.1 Ecosystem of innovators connected to the extension services

Digital agriculture technologies require talent in science and entrepreneurship. On farm support for adoption, is critical and will require additional support networks of other farmers, extension officers and consultants. An ecosystem of innovators connected to the extension services and consultants who have established rapport with famers.

Reminding ourselves that all of these new technologies are first, and foremost tools made by people, for people. Technological transformation requires new business models which encourage collaboration and traceability. A lean multi-actor approach focusing on user acceptability, stakeholder engagement and sustainable business models will boost technology and market readiness levels and bring end user adoption to the next stage (Beers 2017).

Fresh perspectives need to be introduced to the industry. This would result in process innovation, increased knowledge and capacity to innovate on the system as a whole. Technology consultants specifically for agricultural technologies and training need a wider offering for these vocations at tertiary institutions.

All of these technologies are important. Anticipating the future and why farmers need to adopt them needs to be stemmed in the belief that there are benefits to applying this technology to the long-term sector strategy. The adoption of emerging digital technology is for the collective good of both farmers and consumers, therefore increasing the value chain for all stakeholders. They have important implications if they are all applied in agriculture.

5 Findings and discussion

Multiple industry dynamics are aligning to create the conditions for an explosion of employee facing technology (Cain,2016). Many of these technologies will be nestled in (Software as a service) Saas applications. Employee uptake should be rapid given 70% of the adult population in New Zealand have access to up to four devices each.

The farm of the future will incorporate all seven digital technology elements under “smart farming” from the term smart devices. It is important for farmers to have proactive, algorithm-driven delivery of customized information for maximizing on farm efficiency of tasks, gains in production and sustainable environmental practice.

Figure 1: Elements of smart farming (Xin & Zazueta, 2016, p. 276)

5.1 Digital Technology and smart farming

Digital technology is the process of digitizing - converting large amounts of information into symbols representing words and images. Digital technology enables immense amounts of information to be compressed on small storage devices that can be easily preserved and transported (Compaine, Benjamin M, 2001).

Farms of the future will be using connected rainwater sensors that speak to smart irrigators, while sensors measure soil quality and fertilisation. Pasture no longer measured manually but using satellite information, all the data feeding back to a central hub. This data will be processed at speeds that allow real time decision making and action all the while providing intelligent insights in a way that would take the classical computer thousands of years to compute in a matter of seconds.

5.1.1 Artificial Intelligence (AI)

Artificial intelligence (AI) is an area of computer science that emphasizes the creation of intelligent machines that work and react like humans. Some of the activities computers with artificial intelligence are designed for include speech recognition, machine learning, planning and problem solving (Technopedia, 2017).

The capabilities of AI are increasing by leaps and bounds, and machines are beginning to comprehend things at a near-human level.

A huge aspect of AI in agriculture has to do with robotics. Although robots have been around for decades, only in the last several years their skills have grown to a level that can be useful to a farmer. The great part about artificial intelligence is that it's always being optimized as it's fed more data.

Blue River Technology has developed a smart attachment to a tractor that determines different treatments for each plant, depending on its health. Additionally, it can differentiate between plants and weeds by leveraging big data, and actively sprays pesticide on the weeds, but ignores the plants. The more that their smart tractors are used, the more data that they collect to make better decisions when farming in the future.

5.1.2 Virtual reality (VR)

(VR) is an artificial, computer-generated simulation or recreation of a real-life environment or situation. It immerses the user by making them feel like they are experiencing the simulated reality firsthand, primarily by stimulating their vision and hearing (Burdea and Coiffet, 2003).

Pepper, a New Zealand company have created a virtual training setup where a user can receive effective, high quality training without having any additional cost or time to physically set training environments. Users can rehearse before committing to an actual procedure such as major overhauls or repairs to machinery. VR allows the user to be trained with any number of different scenarios.

It also gives the ability to control and manipulate what would normally be uncontrollable such as extreme weather, size and demeanor of herds, the human factor – allowing for different types of impairment eg eyesight and tiredness.

5.1.3 Augmented Reality (AR)

(AR) is a technology that layers computer-generated enhancements atop an existing reality in order to make it more meaningful through the ability to interact with it. It is "a live direct or an indirect view of a physical, real-world environment whose elements are augmented by computer-generated sensory input, such as sound, graphics or GPS data" (Stanney, 2016).

AR is developed into apps and used on mobile devices to blend digital components into the real world in such a way that they enhance one another but can also be told apart easily.

It's still very early days in AR, and there's a great deal of room for improvement. One development that is likely to occur sooner rather than later is voice operation, enabling hands-free control of the AR experience, including which overlays are active and how they are combined. With voice control, a farmer should be able to walk through a field, say what he wants to see, and make modifications to the plan controlling the robotic machinery that actually operates the farm, or issuing commands for execution by the first available machine. For most, this will be a more intimate and far richer connection to their land than what they currently experience.

5.1.4 Blockchain

At its heart, a Blockchain is a record of transactions, like a traditional ledger. These transactions can be any movement of money, goods or secure data (Crosby & Nicchiapang, 2015).

It is real time information sharing versus the traditional way of sharing. Imagine working on the same shared document on google drive. The ability to make changes to a shared document while another person is working on is limited. The problem with that scenario is that you need to wait until receiving a return copy before you can see or make other changes because you are locked out of editing it until the other person is done with it.

E-business adoption rates in the agri-food sector are rather low, despite the fact that technical barriers have been mostly overcome during the last years and a large number of sophisticated offers are available. However, concerns about trust seem to impede the development of electronic relationships in the agri-food chains as trust is of particular importance in any exchange of agri-food products along the value chain.

Drawing on existing research, characteristics and dimensions of trust are initially identified both in traditional and in electronic B2B (Business-to- Business) relationships and a typology of trust is proposed. Blockchain is a list of transactions that is shared among a number of computers, rather than being stored on a central server making data transactions, traceable and incorruptible at the same time. Because the database is not stored in one single location, there is no centralized version for a hacker to corrupt and records are truly public and easily verifiable.

The agricultural industry could see increased global exchange of produce through the exchange of digital products and currency. This could affect everyone from rural farmers selling to consumers across the globe, to large nations accurately tracking their aid relief. This could lead to fairer distribution of goods and currency amongst some of the poorest regions of the world, as well as increase community-based agricultural models on a global scale.

5.1.5 Internet of things (IoT)

The Internet of things is a network of internet-connected objects able to collect and exchange data using embedded sensors (Ashton, 1999).

IoT is part of a future in which digital and physical entities can be linked, by means of appropriate information and communication technologies, to enable a whole new class of applications and services (Miorandi, 2012).

Farmers can use their smartphones to remotely monitor their equipment, crops, and livestock, as well as obtain stats on their livestock feeding and produce. They can even use this technology to run statistical predictions for their crops and livestock.

Three common precision agricultural information technologies are global positioning system (GPS) guidance systems, GPS yield and soil monitors/maps, and variable-rate input application technologies (VRT). These three technologies show different adoption growth rates over 1998-2013, with guidance systems used on about half and VRT on about a fifth of planted acres in 2010-13 (Schimmelpfennig,2016).

Internet of Things applications in agriculture include farm vehicle tracking, livestock monitoring, storage monitoring, and much more. Today, a driving force behind increased agricultural production at a lower cost.

Moocall is among the Irish companies leading the way in farming and agri-tech innovations. The company's calving sensor warns farmers when a cow is one hour from birthing to ensure cow and calf are cared for in the event of a difficult birth. The device works by monitoring the movement of a cow's tail in order to predict when labour is imminent. Farmers no longer need to monitor CCTV or visit calving sheds, as the Irish-designed device will send a text message when the cow is going into labour. The IoT is set to push the future of farming to the next level.

5.1.6 Quantum Computing

Quantum computing is next generation computing which may one day lead to revolutionary breakthroughs in materials and the optimization of complex manmade systems, and artificial intelligence.

Nature follows the laws of quantum mechanics, a branch of physics that explores how the physical world works at the most fundamental levels. At this level, particles take on more than one state at the same time and interact with other particles that are very far away. Quantum computing harnesses these quantum phenomena to process information in a novel and promising way.

This means a quantum computer can process in a few seconds what would take a classic computer thousands of years to process (Beal, 2017).

Present computational methods and models provide us means to study the problem, but these tools have not yet been sufficient to answer some of agriculture’s problems. However, the technology still needs to mature in order for it to become fully enterprise-ready and deliver meaningful, cost-effective business results.

Applications will include improved weather forecast and climate change prediction, improved online security and AI. Instead of troubleshooting issues bit by bit as we do now with classical computers, quantum computers tackle the entire problem at once.

Nanotechnology has the potential to change every part of our lives. Nanotechnology affects all materials like metals, ceramics, polymers, organics and biomaterials. In the coming decade nanotechnology will have an enormous impact in all areas of life (Aithal, 2015). Future advances could change our approaches to manufacturing, electronics, IT & communications technology, space technology, agriculture & food technology, renewable energy, biotechnology and medicine, making previous technology redundant and leading to applications which could not have been developed or even thought about, without this new approach. Nanotechnology will play major role in solving all the problems of humans like food, drinking water, energy, health, environment and many other areas including life span expansion.

6 The Role of ICTS in agriculture

Social and business innovation is driven by the intelligent use of information and communication technology.

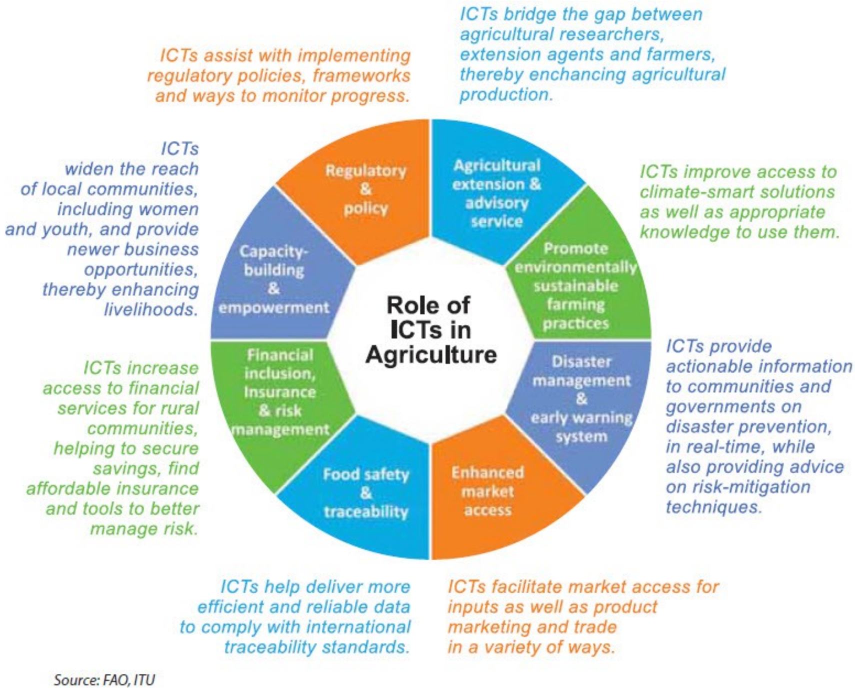


Figure 2: The Role of ICTS in agriculture categorized by application

While there have been many introductions of ICT in the food sector (precision agriculture, tracking and tracing along food value chains, consumer communication, agricultural information exchange, logistics, and identification of product characteristics on labels), and numerous farm management tools used by farmers and rural professionals across Australasia, there remains limited widespread adoption of innovative technologies, and many of the existing tools focus on single or limited-range processes (Allen & Wolfert, 2011; Lehmann, Reiche, & Schiefer, 2012; Verdouw *et al*., 2014).

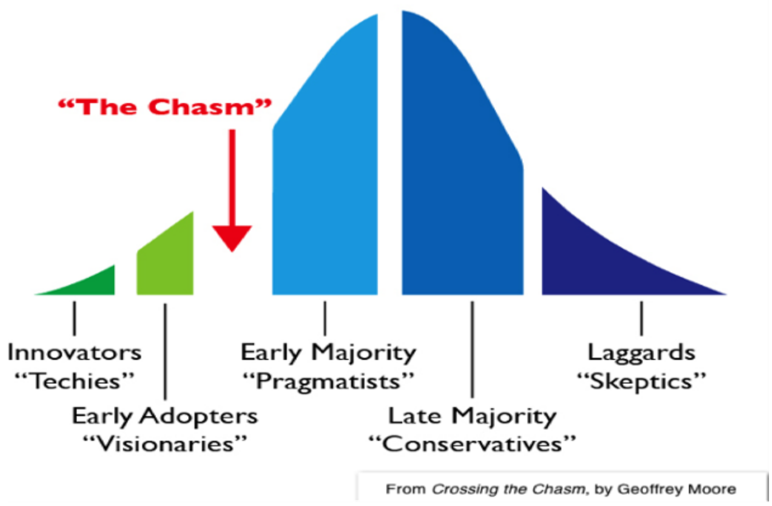
6.1 The ICT Adoption Cycle

New Zealand is very well placed for adoption of digital tech in agriculture. Sitting in the 9% of industrialized agricultural nations, university and research institutions attract the best talent to work on solutions for agriculture. The intersection of well-funded research, top talent and socio-economic status could lead to innovation in agriculture and subsequent sticky adoption and implementation.

It is suggested that the average farmer or farm consultant would not know of the complete range of tools that are at their disposal. While market forces will dictate that the more successful/useful tools will rise to prominence, there are nevertheless likely to be tools that would help a particular farmer/consultant that are not being used simply because they were not aware of them (Allen, 2015).

6.2 Human Capital – discovering the adoption chasm

Human capital has been identified as the most important factor in technology transfer (Rogers, 1995). The ICT adoption cycle follows a simplistic sociological model for a three-step phase: innovations, access to the innovations and use of the innovations. Adoption is according to the demographic of the defined adopter groups.



Source: Moore, G.A. 1999

Figure 3: A categorization of technology transfer has been categorized according to five types of people.

The innovators are the first adopters. They are willing to take risks, youngest in age, have great financial liquidity, are very networked and have close contact to scientific sources and other innovators. I believe this is where farmers are sitting with digital technology adoption.

Early adopters are the second fastest to apply new technologies and are regarded as leaders by people in other categories. The early majority who tend to be slower in adoption but have contact with early adopters. The late majority tend not to be financially.

At the tail end of the adoption curve are the laggards. They are the last to adopt new technologies. Laggards or resistors may be an important sector to focus on for farmer adoption as a large proportion are likely to leapfrog technology, they move to smartphones despite not having used a computer (Moore,1999).

7 Conclusions

The role of IT has been more focused on 'keeping the lights on ', and as a result there is little funding for innovation. There is a gap between the future as perceived by technologists and the future as perceived by many agri-food industry participants. Rarely is it seen as being strategic, disruptive, or game changing.

The discussion needs to be much larger than what gadgets have come out and how they will improve our productivity. Emerging technology is no longer a "nice to have," it is table stakes. While technology is no substitute for the human element, when used strategically and appropriately, it helps overcome hurdles and brings buyers and sellers together for the greater good of both.

Technologists believe disruptive change will impact the industry at an unprecedented rate, fundamentally and substantially changing business practices and models, while industry participants often perceive that technological change will be incremental, manageable, and supportive, in broad terms, of the status quo.

A literature review shows there are a number of technologies that farmers could be using (OECD, 2017). Of particular interest for this study are Artificial intelligence (AI), Virtual Reality (VR), Augmented Reality (AR), Blockchain, Quantum Computing and the Internet of Things (IoT) and their applications for agriculture as technologies that disseminate knowledge.

Agritech firms have a significant opportunity to be the 'go-to' solutions providers. They will need to have grasped a genuine understanding of how and why the agribusiness can gain value from emerging technologies and on sell that value proposition. To be in a position to do this would require a generous amount of funding to back research and development efforts from these firms. Currently help is available in the form of grants from Callaghan Innovation as well as a tight knit private investment community.

The fundamentals to the adoption of technology on farm are double sided. Double sided because for the effective use and return on investment for the use of technology all stakeholders need to be actively engaged in its implementation. The providers of the technology will realise a return when farmers adopt and use the technology repeatedly. Making it better and more efficient. The farmer benefits when the technology improved to better meet their needs and requirements. An interface to bridge the digital divide will allow support for sticky adoption of emerging digital technologies;

Farmer facing

- Access to the appropriate expertise
- Dedicated resources directed at farmers as the end users of emerging technologies.
- On farm, or adoption support.
- Having the right learning environment

Provider facing

- Clarity of the issue or challenge being addressed
- Technology is suitable for issue or challenge being addressed

- Having strategies in place that will ensure farmers understand and get the perceived value of adopting emerging technology.
- Lifting the profile of on farm innovation for the greater good and industry wide application.
- Information, Instruction and competence of users of the technology
- Embracing diversity of thought and exploring new ways of doing things on farm all the way along the supply chain

The implications for the farmer are that big data is expected to have a large impact on Smart Farming and involves the whole supply chain. Smart sensors and devices produce big amounts of data that provide unprecedented decision-making capabilities. Big data is also expected to cause major shifts in roles and power relations among traditional and non-traditional players. Governance and business models are key issues to be addressed in future research (Wolfert, 2017).

8 Recommendations

- Conversations around succession planning, should include technology and the subsequent threats and opportunities it presents for agribusiness sector wide. Technological change is here to stay and in a big way. In the last year alone, technological advancement has by necessity moved its applications from the daily convince category to a business strategic focus. Extension activities aimed at farmers will help farmers gain an understanding of the benefits that come with interconnected platforms on the farm sharing data and optimization of output with minimal input through adoption of digital technology.

- Farmers need to invest the time and effort into technology implementation and change management have become critical transferrable skills that farmers cannot afford to overlook. It is time to become in familiar landscape of emerging digital technology. The digital divide needs to be for farmers by incorporating technology training into the curriculum for tertiary institutions offering agribusiness related courses of study.

- Farmers need to take a more proactive interest in the creation of solutions to their problems by investing in new technology that can be exported globally.

- There is a need for cross sector collaboration, which could be in the form of an innovation ecosystem involving extension service providers working closely with innovators and consultants. The sector could also borrow skills from other business sectors that have gone digital to implement change in the move towards emerging technology.

References

Allen,J . (2014). Framing for the future; towards better information-based decision-making and communication. Ag first

Beal, A. (2017). Inside the world of quantum computers. Wired; UK

Bench-Capon, T.J.M., Dunne, P. E. (2007). Argumentation in artificial intelligence. Liverpool: ACM Library

Burdea,G.C, Coiffet,P. (2003) . Virtual Reality Technology, 2nd Edition, ISBN: 978-0-471-36089-6

Cain,M.(2016). Top 10 Emerging Technologies in the Digital Workplace. Gartner Inc

Compaine, Benjamin M. (2001). The Digital Divide: Facing a Crisis or Creating a Myth? .Cambridge:Mass.: MIT Press

Crosby,M.,et al.(2015). Blockchain technology beyond bitcoin. Sutardja Center for Entrepreneurship & Technology Technical Report .

Elayan,H., Shubair R.M., Almoosa,N.(2016) Revolutionizing the healthcare of the future through nanomedicine: Opportunities and challenges. *Innovations in Information Technology (IIT) 12th International Conference*

Finistere ventures & pitchbook : 2017 Agtech Investment Review

Gerard,S.(2013/14). Information and communication technologies for sustainable agriculture: Indicators from Asia and the Pacific. FAO

Grier R.A., Thiruvengada H., Ellis S.R., Havig P., Hale, K.S. (2016). Augmented Reality – Implications toward Virtual Reality, Human Perception and Performance. Holland

Kelly, S.J (2017) Disruptive technology in the agri-food sector: An examination of current and future influence on sustainability, bio-security and business effectiveness.

Kim, Henry M. and Laskowski, Marek, Towards an Ontology-Driven Blockchain Design for Supply

Kurzweil, R. (2006). The singularity is near: When humans transcend biology. Penguin books

Miorandi, D. (2012). Internet of things: Vision, applications and research challenges. Ad hoc networks

Ministry of business innovation & employment: Annual Report (2016)

Moore, G. A. (1999). Crossing the chasm: Marketing and selling high-tech products to mainstream customers. New York: Harper Business.

MPI. (2012). Survey of technology transfer services to farmers and growers in New Zealand

Newzoo's Global Mobile Market Report, April 2017]
Viviano, F. (2017). This tiny country feeds the world. National Geographic

Wolfert,S. (2017). Big Data in Smart farming. Science direct

Sutardja Center for Entrepreneurship & Technology Technical Report, [2015]

Schimmelpfennig,D. (2016). Farm Profits and Adoption of Precision Agriculture .ERS

A report on a Survey of New Zealander's use of smart phones and other mobile communication devices, 2015

Journal of the Association for Information Systems Vol. 6 No. 12, pp. 298-337/December 2005

The global innovation index, [2017]
Computers and Electronics in Agriculture Volume 70, Issue 2, March 2010, Pages 321-327

http://www.beeflambnz.com/your-levies-at-work/future-farms-initiative

https://blockchain.org.nz/what-is-the-blockchain/

Chain Provenance (August 23, 2016). Available at
SSRN: https://ssrn.com/abstract=2828369 or http://dx.doi.org/10.2139/ssrn.2828369

http://www.mbie.govt.nz/info-services/business/business-growth-agenda/sectors-reports-series/pdf-image-library/information-and-communications-technology-report/2015%20Information%20and%20Communication%20Technology%20report.pdf

https://www.businessinsider.com/intelligence/research-store?IR=T&utm_source=businessinsider&utm_medium=content_marketing&utm_term=content_marketing_store_text_link_what-is-the-internet-of-things-definition-2016-

8&utm_content=report_store_content_marketing_text_link&utm_campaign=content_marketing_store_link&vertical=iot#!/The-Internet-of-Things-Report/p/59665942

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