Agriculture and Innovation

What farmers can do to be part of the digital revolution

A report for:

By Murilo Martins Ferreira Bettarello

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Scholar Contact Details
Murilo Martins Ferreira Bettarello

Organizations: IZagro www.izagro.com.br) ViaVerde Tropical Agriculture Advisory Company

www.viaverde.agr.br

Av São Vicente, 5052 – Franca/SP – Brazil – CEP: 14403-830

Phone: +55 16 981320051

Email: murilo@izagro.com.br mbettarello@viaverde.agr.br

In submitting this report, the Scholar has agreed to Nuffield International publishing this material in its edited form.

NUFFIELD INTERNATIONAL Contact Details:

Nuffield International

Telephone: (+61) (0) 3 5480 0755

Facsimile: (+61) (0) 3 5480 0233

Mobile: (+61) (0) 412 696 076

Email: jimgeltch@nuffield.com.au
Contact: Jim Geltch

Title: Chief Executive Officer

Address: PO BOX 586, Moama, New South Wales, Australia 2731

Executive Summary

Discussions with all kind of farmers and agriculture enterprises, from a 0,5 hectare coffee farm in Kenya, to a 30,000 soybean hectares farmer in Brazil, reveal that all of them are feeling the impact of the digital revolution. Disruption that has occurred in shopping (Amazon), movies (Netflix), media (Facebook) and research (Google), are evidence of the change that agriculture is going to face in the next 10-15 years. The question is, are farmers going to be part of this revolution, or they going to be passengers? How they can play a fundamental role in this change? How they can be prepared for this change and benefit from it?

This report points out the trends which are likely to occur in digital agriculture in the next few years, and also shows some startups which are building innovative solutions for agriculture. Some of these are going to succeed, but a lot are going to fail. “Fail fast” is a desirable strategy in the startup world. That is one component of the culture of the startups that which can be adopted by the traditional agricultural world, to more rapidly develop agriculture innovation and be prepared for the next big changes that are going to come.

This report also shows the importance of hubs of collaboration and how farmers unions, cooperatives and associations can join to create hubs promoting innovation and change to solve the complex problems that our nine billion person world population is creating. It is worth noting that 10 of the 17 sustainable development goals (SDG) that our society aims to achieve by 2030 are directly linked to agriculture. This report gives some idea of how the digital revolution is going to help solve these complex challenges. In 5-15 years, we are going to have drones, controlled by apps, drought and disease proofing our farms or robots harvesting our trees; some examples of these already exist. The challenge is to make all this technology available for the majority of farmers and to teach these farmers how to use these innovative tools to help them grow more, better and more sustainable food to feed our growing world.

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Summary

Foreword

Although my family doesn't have a background in farming, I started farming at 13 years old. This came about from big doses of entrepreneurial thinking from my Dad, who gave me 15 calves to grow out with my best friend, whose dad was a cattle farmer. By the time I was 18 years old, I had around 150 cattle and remember thinking I was a rich and big farmer that did not need to attend university. Luckily my Mum is a clever lady and convinced me to try agronomy, where I realized how important technical information is to help farmers improve their farms and to be competitive players in the market. After university, I wanted to spread the best agriculture knowledge I could acquire to as many farmers as possible, so I joined a consultancy (of which I am now a partner) and I worked all over Brazil, Latin America and Africa as a consultant to farmers, to help them achieve better agricultural results. That 10 years of travel gave me a solid understanding of the main problems that farmers have, as well as understanding the fundamental and technical approaches needed to address global agricultural challenges. I became more and more interested in what can be done to broaden this technical assistance in a meaningful way. Not many people were talking about digital technology in Brazilian agriculture in 2015, but the intersection between agriculture and the new world of digital technologies excited me and I invited some friends to build a mobile app. The result was IZagro, designed to support farmers with technical information and connect them with agronomists and local retailers.

Through my personal interest, now supercharged by the Nuffield Scholarship, I started studying digitally-driven business models, which included aspects of impact and disruption, collaborative tools, innovation hubs and accelerators. I re-directed my enthusiasm and commitment to show that farmers, in the era of internet connectivity, need to adopt new digital tools to approach their markets and consumers. This need to innovate is now greater than ever and this collaboration and intersection can come together with other big challenges, to attract a new generation of farmers and thus promote long-term sustainability.

My Nuffield experience has injected my already strong interest, knowledge and enthusiasm for agriculture to another level, and I am grateful to be part of this innovation hub of ag-leaders on my journey of learning that will be for forever.

Acknowledgments

I joined Nuffield thanks to two elements – luck and a desire for self-improvement. It all started when I saw a post on social media by João Martins, a CSC 2016 Brazilian delegate who was at the CSC in Ireland. I put the application on my “to do” list, but I didn’t realize until I attended the final selection interviews in São Paulo just how big and transforming Nuffield is.

There are numerous people and organizations that I would like to thank for their support over the course of my Nuffield experience.

Firstly, I would like to thank my sponsors NUFARM. Without their essential support this life changing journey would not have been possible. Thanks for believing in the importance of supporting young agriculture leaders. I will always have a debt to you.

Also, would like to thank Nuffield International and Jim Geltch for always being available, and the Nuffield Brazil team, who are driving to a global agriculture mind set to Brazilian leaders. Thank you especially to Sally Thomson for always supporting, believing and encouraging me to challenge myself to make good and courageous questions.

Also, thanks to the ViaVerde and IZagro team that keep our businesses running and were there for our clients; without these people it would be impossible to spend 18 weeks travelling and learning.

And, most importantly, thank you to my wife Ana. It’s not easy leave home for 18 weeks in this journey with Rafaella being only 12 months old. Ana, as always, showed her warrior behavior and kept our house and family together; your support made my homesickness tolerable.

Abbreviations

Advanced Farming**:** The research activities that are designed to advance Digital Agriculture to achieve improved productivity and sustainability over the long-term, e.g., predictive phonemics.

Agtech - Agtech is a broad term that can mean different things to different people. For the purposes of this report I take it as the intersection between agriculture and technology. This can include technologies that interface with farmers, as well as those outside the farm gate, such as biotech, and the consumer.

AI - Artificial Intelligence is used to describe machines performing human-like cognitive functions

Digital Agriculture**:** A family of activities related to farming that includes Precision Agriculture, Prescription Agriculture, Enterprise Agriculture, use of Apps, use of the Internet of Things (IoT), tools and sensors. It depends on the collection, use, coordination and analysis of data from a multiplicity of sources, with the goal of optimizing productivity, profitability and sustainability of farming operations.

Digital Transformation refers to the challenges and changes associated with digital technology application and integration into all aspects of agriculture. It is the move from the physical to the digital.

Innovation Hub - A location where people purposefully connect together (either physically or digitally) to develop new ideas and work together to solve common problems in an innovative way.

IoT - The Internet of Things (IoT) refers to applications and services that are driven by data collected from devices that act as sensors and interface with the physical world.

Open Innovation - An innovation model that assumes that useful knowledge is widely distributed and that even the most capable R&D organisation must connect to and leverage knowledge outside the business as a core process in innovation. It is opposite to the traditional vertical integration model where internal R&D activities lead to internally developed products that are then distributed to business.

Objectives

The main objectives of this report are

- to identify some innovation initiatives that are part of the digital agriculture revolution.
- to identify key issues that are now, and in the future will affect farmers.
- to outline how we can be part of it.

Leading in from these over-arching objectives, this report aims to achieve the following:

1- Identify the main areas of digital innovation in agriculture and what agtech trends we see around us.
2- Examine the agriculture innovation hubs and what are they doing to connect farmers into the digital era.
3- Identify what farmers can do to adopt innovative agricultural tools and take advantage of digital technology.

Chapter 1: Introduction

FARMERS – THE ORIGINAL ENTREPRENEURS

Innovative farming has been around a long time before the word entrepreneurship became commonplace, but in a world which is changing faster than ever, farmers who are more adaptable and who adopt a startup mindset are going to be the ones that achieve more success. 10,000 years ago, when humankind started to cultivate some plants, humans shared knowledge and built deep connections between each other around the fire during the night. This evolution in connectivity was a simple, yet profound, jump in our development as a society, and was a game-changer in agricultural thinking and practices and triggered a wave of change that has increased both population size and general health.

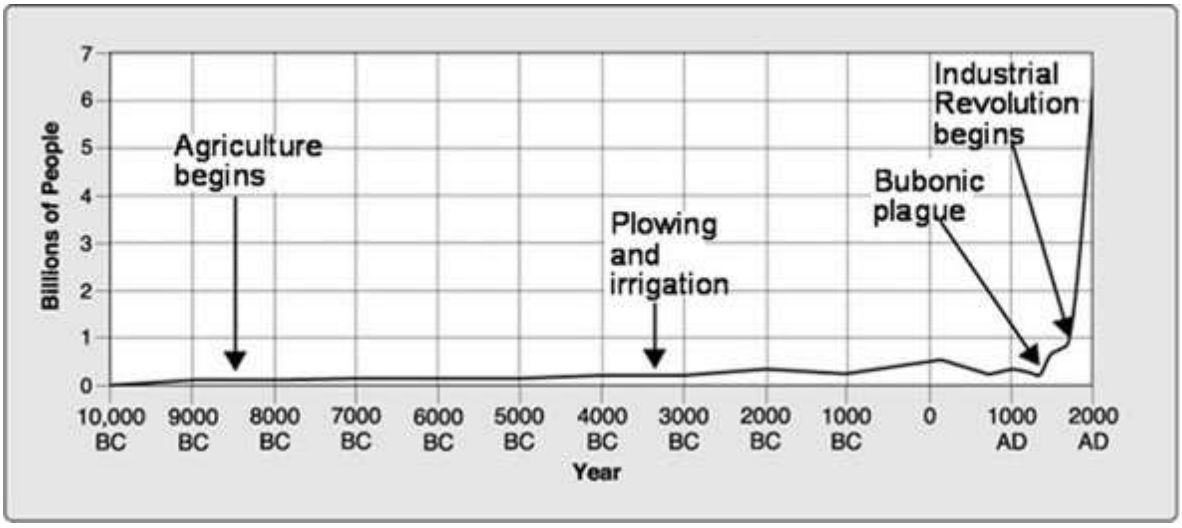

Figure 1:The link between the growing world population and technology revolution.

The Industrial Revolution of the eighteenth and nineteenth centuries then shifted the predominantly agrarian society to an urban and industrialized one, with powered and special-purpose machinery replacing largely home-made tools and basic machines (Figure 1). The Green Revolution of the mid-twentieth century then brought revolutionary improvements in crop yields worldwide and particularly improved research and transfer of technology into the developing world.

The agrarian, industrial and green revolutions brought many improvements in the standard of living for mankind. This increased agricultural productivity also produced some adverse environmental effects. Where population pressure is high, however there is no option except to produce enough food to sustain the demand. Looking forward, we continue to acknowledge the need for increased productivity, but the focus now is on ways which are environmentally safe, economically viable and socially sustainable. This fourth revolution has been christened the “Evergreen Revolution” and digital technology is at the heart of this new world system.

INTRODUCING AGTECH AND STARTUPS

Many studies have shown that we must produce more food in the next 30 years than during the entire course of human history to date, and that we must do so on a planet showing signs of severe environmental stress,

In this fast world of changes, startups are solving problems across different industries. The last three years has seen a flood of agriculture solutions to help farmers embrace some key agricultural challenges. Known broadly as “agtech,” these farm and food-linked innovations and startup businesses use scale to impact and help more people by building solutions that solve problems in an efficient and simple way. But for the Evergreen Revolution to be genuinely successful requires sustained attention, significant investment and the need to join diverse players together with a focused goal.

I believe that farmers are among the key players facing this challenge, as they always prove to be resilient, creative and most importantly are at the heart of the sector. For me, the most difficult part in this process is to connect the digital world with our practical and straight-forward farmers. As seen in countries, including Brazil, USA, European Union, Israel, India, Kenya, Denmark, Argentina and United Kindom, the challenge also presents much opportunity.

According to Agfunder (2017), investments are booming, with early stage investment in agrifood tech startups reaching U$10.1 billion in 2017. Furthermore, a 29% year-on-year increase is forecast, reversing the short downward spike of 2016 when agrifood tech investments dropped 9% to U$7.8 billion from being up at U$8.6 billion in 2015 (Figure 2).

So Agtech is blooming, but beyond investments, innovation and hype, Agtech can be a movement involved in changing the mindset of conventional agriculture, and promote the innovations that most of successful farmers have and adopt. Agtech movements can promote better images, connecting farmers to urban citizens, and also bringing young people back to farming. This movement is often being led by startups.

What is a Startup? *“A startup is a human institution designed to create a new product or service under conditions of extreme uncertainty.”* (Eric Ries, Lean Startup methodology). This quotation is a phrase stated by one of most respected authors in the field of startups. So, farmers have a lot in common with the startup mindset, but the main difference is usually startups aim to gain scale and to focus on a product-market fit that is deeply engaged with costumers to solve their problems. Although farmers are very innovative and work in extremely uncertain conditions, they barely know their costumers and do not usually focus on their consumer’s experience.

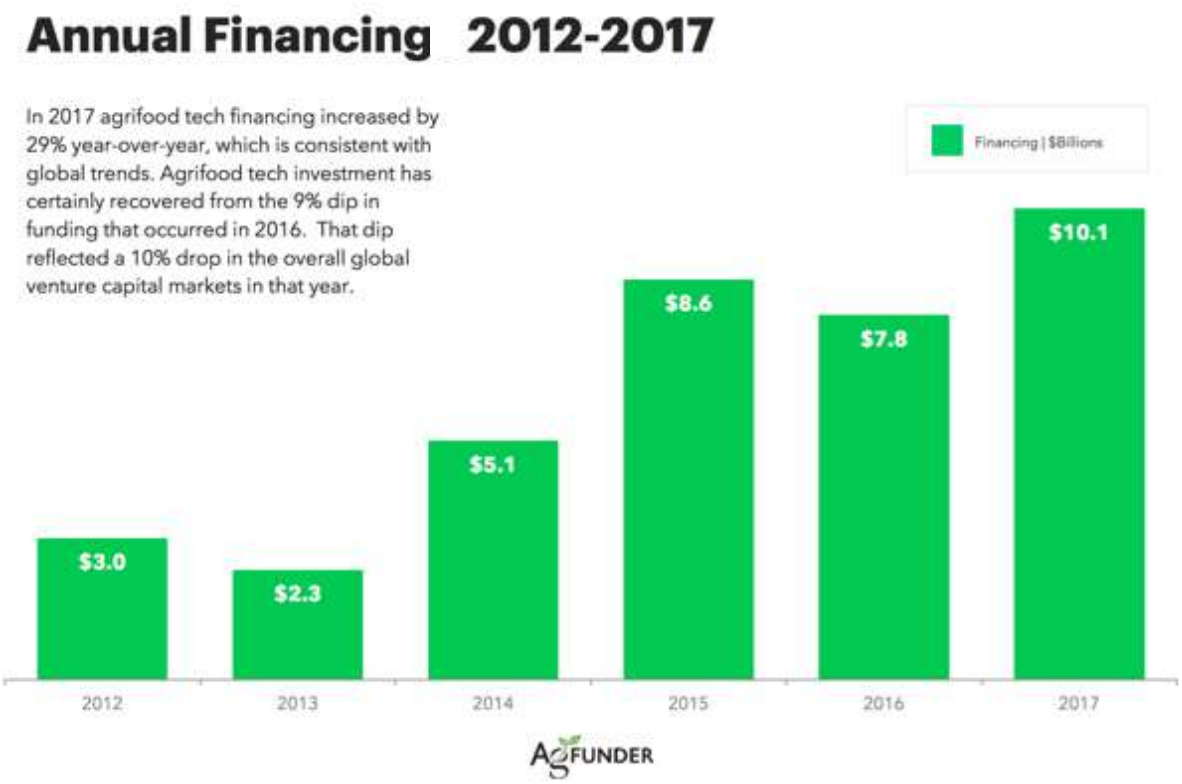

Figure 2: Agfunder financial report 2012/2017

The mega-trends driving the digital agricultural revolution are listed in Figure 3 below. (Delloite Agtech report 2017):

1- **Growing Population** – the world population will reach around 10 billion in 2050. Some developing countries will experience increased incomes. Populations will demand more proteins, meat and other resources. Farmers will need to produce more with fewer resources and do so sustainably.
2- **Urbanization** – 50% of the population will live in urban areas. How can we connect these consumers to the farms and get them to appreciate the value of their food?
3- **Agriculture technology** – New digital technologies will trigger higher yields and may include cost reductions. Farmers need to take care not to fall in the trap of producing a lot without a profitable market.
4- **Societal Changes –** The dynamics of society and population growth will demand a more intensive use of resources.
5- **Climate change -** Changing weather conditions will increase farm financial volatility and risk, which will challenge current production methods.
6- **Globalized trade –** Companies are becoming more and more international and crops are being growing in more suitable places, and then being processed overseas.
7- **Biotechnology –** Genomics, fast discoveries and other technologies are helping improve varieties for yields and plant resistance.
8- **Integration in value chain –** Big companies are vertically integrating to

optimize the value chain and get value from every level of production.

9- **International regulation -** while agricultural production is often a fundamental driver for a developing country, imports are restricted by some developed countries, where agriculture plays a small role in the GDP, to protect their markets
10- **Servicization** – Agronomic suppliers are going to have a big role in offering service and education for farmers in the use of new digital tools.

In order to deal with these massive trends startups will need to work in a complex and growing world. This means that startups will need to specialize in servicing various areas of the innovation process and operate at different levels in the agricultural service chain.

Areas of operation of a Startup:

The fast pace of change coupled with a relatively new business concept of failing fast means that it is not valid or relevant to list successful startups here, as the list will quickly become outdated. It is more valuable to highlight digital agriculture trends and how farmers can be part of this innovation wave, which can be split onto three key areas:

Startups usually are focused on solve the unique problems of an area in an innovative way, so farmers and entrepreneurs can work together to focus on different parts of the agriculture chain defined above:

Pre-farm gate startups refer to an integrated network of companies, such as input manufacturers (i.e. seeds, beneficial insects, microbes, fertilizers and plant nutrition), digital procurement and inputs, credit or insurance facilities for farmers, marketplaces and fintech.

On-farm startups include those working with farm management software, mass education platforms, scouting and pest monitoring platforms, remote sensing and image data processing (i.e. IoT, drones, etc.), equipment and machinery.

Post Farm Gate - As food leaves the farm, a vast network of distribution and trading, processing, energy, traceability and food assurance, storage and monitoring, restaurant marketplace and food innovations are being created to match changing consumer demands.

Do these Investments Reach the Farmer?

Farmers have varied responses to risk. They are conservative and the same time some of the most risk-taking entrepreneurs, considering the high levels of climate and market variability they encounter. Dealing with these big risks on a daily basis, they sometimes avoid exposure to other risks like new technologies, instead waiting until their neighbours start to use it and prove its value. A farmer that was part of an Agtech meeting in Brazil reinforced this, saying that farmers are some of the most innovative entrepreneurs, and they adopt new technologies:

- when they see the value of producing more or by decreasing their costs or

- their neighbor told him that it was worth it.

An avocado farmer in a Kibutz in Israel told me that they think technology is very important but they do not use “fancy stuff” and they have difficulty in using some tools. However, walking around in his avocado plantation, I saw some IoT sensors and was shown the software management tool being used to track plagues (Figure 3). Here I realized that when technology and tools are simple to use and do not make people feel uncomfortable, adoption is much easier. In order to reach a big proportion of farmers, developers need to keep the solutions simple and easy to use.

Figure 3: Visiting an Avocado Kibutz in Israel

Another example is a 0.5 hectare coffee farm in Kenya, where standard cellphones are used to purchase agriculture products from the cooperative and to record harvest yields; these reports are delivered daily by motorbike (Figure 4).

Figure 4: Kenyan farmers buy, receive and pay for inputs using SMS cellphones.

Agriculture is a big market full of different businesses, production methods and cultural behaviors. Although there may be a lot of similar issues between farmers in Australia, Brazil or Kenya, the daily realities of these farmers are often completely different. This is one of the biggest insights obtained from my Nuffield travels – that a 2 ha farmer in India or Kenya has different priorities and connections to each other, let alone compared to a farmer in EU with 50ha or a farmer in US with 1000 ha. On the other hand, all farmers are affected by the digital transformation and in the last two years there have been a range of shifts in various agricultural trends.

Chapter 2: Collaborative hubs in the agricultural world

Today's farmers face a lot of complexity in the decisions they need to make, from decide best inputs (seed, fertilizer, chemicals etc.) they need to use and buy, deciding on the best agriculture practices to adopt and also the best way to sell or finance their crops; in the near future they will need to decide what digital tools they need to use in order to remain competitive. In that there is a lot of uncertainty about how farmers can interact and be part of this Agtech movement and use the best solutions to their benefit. This report challenges farmers to think beyond the immediate future and be part of a collaborative approach to developing novel solutions and not just be passive users or clients of these new startups.

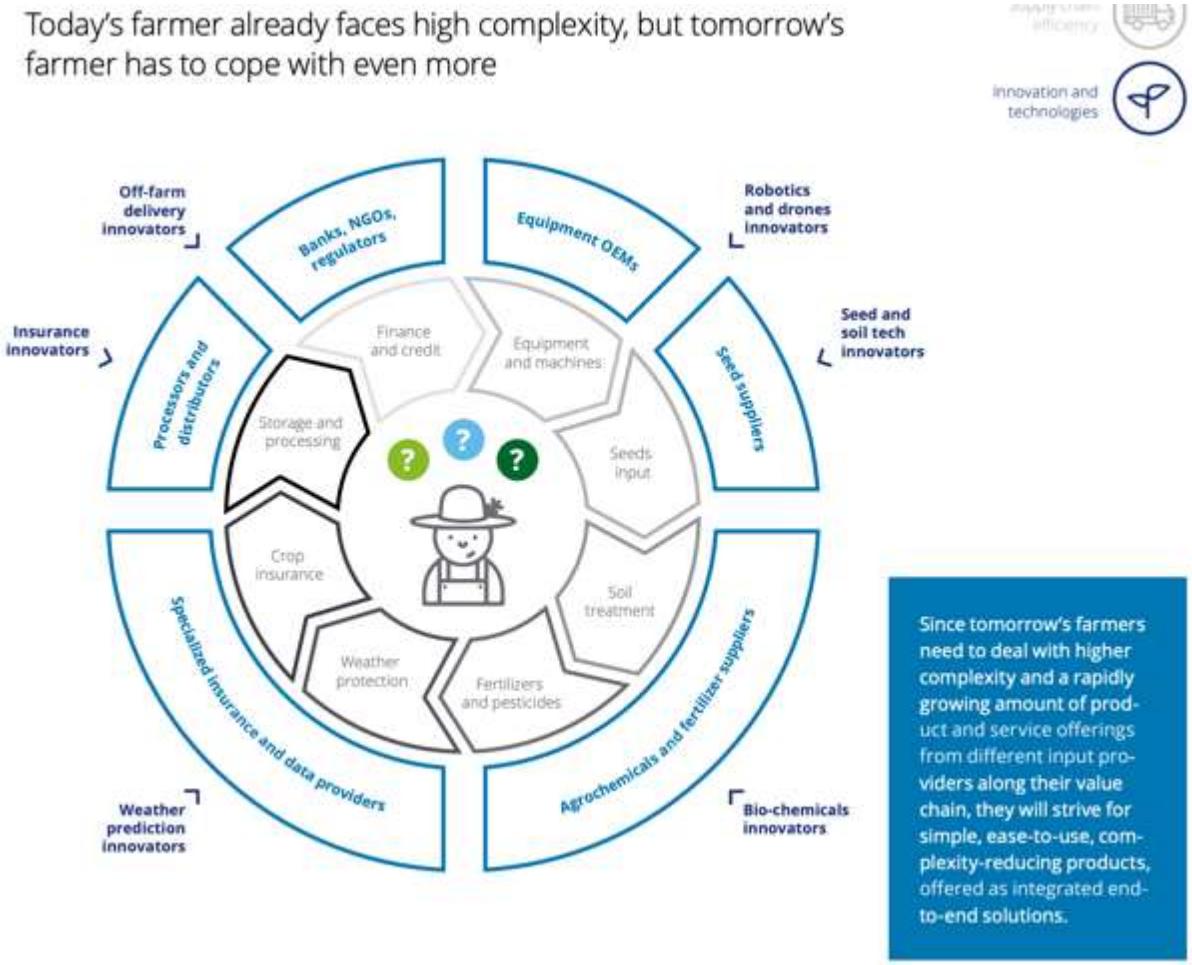

Figure 5: Delloite Agtech report – Farmers complex interactions

Collaborative hubs in the agricultural world

Figure 5 shows that society always evolves through groups, and great ideas are very rarely developed in the hands of one single person, as Steven Johnson explains in "Where do Great Ideas Come From" (https://www.youtube.com/watch?v=NugRZGDbPFU) and also Steve Jobs reflection about connecting the dots in his famous Stanford Speech (https://www.youtube.com/watch?v=UF8uR6Z6KLc). Both entrepreneurs propose

that great ideas need a maturing time to be built up into practices and that when different people and their different experiences come together that the chance of an idea having a big impact increases. Therefore, to accelerate good ideas and innovation in agriculture, we need to put smart and different people together like they did on Murano Island in Italy in 1291. Fearing fire and the destruction of the wooden buildings in the city of Venice, the government ordered glassmakers to move their foundries to Murano. Some locals thought that moving all the competitors to a small island would ruin the glass business, but what they saw was the opposite. Being together, the glassmakers shared more knowledge, leveraged off more opportunity and developed more technology, from which everybody benefitted. Today, Murano is still famous worldwide for its high-quality glass production.

Given farming often involves big distances and a culture of isolation, how do we bring farmers together to share, think and solve challenges? There are many great examples around the world and they always came with two main ingredients: leadership and connection. A simple analogy for this is that connection can be the soil and substrate and leadership can be the seed or fertilizers. We know from agriculture that one doesn't grow without the other.

The following section describes the state of Ag-Tech, and it's uptake by farmers in various countries visited by the author.

Brazil:

Brazil is a rich environment for ag startups given the relatively young population, large role of agribusiness in the economy and significant growth prospects. In tropical agriculture Brazilian entrepreneurs and startups can play an important role in transferring technology and tropical innovation and collaboration. In the last 30 years Brazil changed from a food importer to the second biggest agriculture exporter in the world, so Brazilian technology can be developed and transferred to countries in Africa, India and Asia. The author spoke with entrepreneurs, big companies and farmers at various agri-innovation events, to understand what drives the establishment of Innovation Hubs, which yielded insights from the following cases.

Piracicaba City– **State of São Paulo** is a key pillar of Brazil's agtech ecosystem. Home to ESALQ University, with over 100 years of history and nominated as one of the best agriculture universities in the world, it is a hotspot for tropical agriculture development. ESALQ University has its own Incubator called ESALQTec which hosts and stimulates young companies. Also housed in Piracicabais is the sugarcane accelerator hub (PULSE), which is a joint venture between Raizen, the biggest national ethanol producer of sugar cane, NXTP, and SP Ventures. In addition, it is home to a cooperative hub of innovation (CANATec) and a co-operative of Agtech companies and innovations called (Agtech Garage).
https://www.pulsehub.com.br/index.html
https://www.esalqtec.com.br/site/

Londrina City – State of Paraná is a very traditional and successful temperate agricultural region and Londrina city is home to important seed breeding companies and head office of some agriculture players like Belagricola and Don Mario. The Rural Farmers of Paraná Society (SRP) founded a hub of innovation and a big technology event call Agrobit.
http://www.srp.com.br/

AgriHub - State of Mato Grosso is the biggest soybean producing state of the world and the state farmers association (FAMATO) have united to promote innovation in agriculture, host startups and take innovative farmers around the world to visit hubs of innovation. They created a farmer group of early adopters, who self-nominate as having interest in testing startup solutions from Brazil and other countries. Startups that want to connect with the Mato Grosso market can join this group and participate in week-long trips where they meet with farmers to get a true understanding of farmers priorities and how to align their products and pitches. This connection is fundamental to building a genuine network and to give startup developers honest feedback about their agritech solutions.
http://agrihub.org.br

Figure 6 shows some of the most important startups in Brazil that are filling an important role from market place to consultancy and soil analyses. If readers want more information about the company they can go to the links shown in Figure 6.

Figure 6: Agtech radar Brazil - Brazilian Agtech Startups that are playing a big role in Agriculture.

Africa

The African continent spends $25 billion annually on food imports, despite its huge production potential, being that it has 60% of the worlds non-cultivated arable lands. Africa can play a major role in taking on current and future food challenges, but it needs to leapfrog the innovation gap to produce enough food for its own population and work toward becoming a food exporter.

Like most people, African farmers can be quite attached to their traditions and therefore reluctant to change, but they are not immune to the technology revolution. Just like in the African banking industry, where mobile money technologies have found their ways into business and life regardless of the almost non-existent banking system, agriculture must follow suit.

With many small landholders in Africa, digital technology offers a range of simple to very innovative solutions to help address farm poverty problems like poor nutrition, access to credit and access to technical information. Simple and inclusive technology such as farmers using SMS to ask about their crops, and receive answers from other farmers or even from an artificial intelligence “chatbot” to explain than what they can do to improve the management of their crop; this can change the game for small farmers. https://medium.com/@wizaj/how-a-20-year-old-mobile-technology-protocol-is-revolutionising-africa-with-numbers-744a52cbea92

Four broad areas challenge the ability for Africa to produce enough food and correctly distribute it around the planet.

- Financing & insurance
- Resources (inputs, equipment, labour)
- Knowledge & know-how (business and agronomic)
- Market (logistics, commercialization, transformation)

Figure 7 below highlights some agtech companies that are making a difference in the Africa continent.

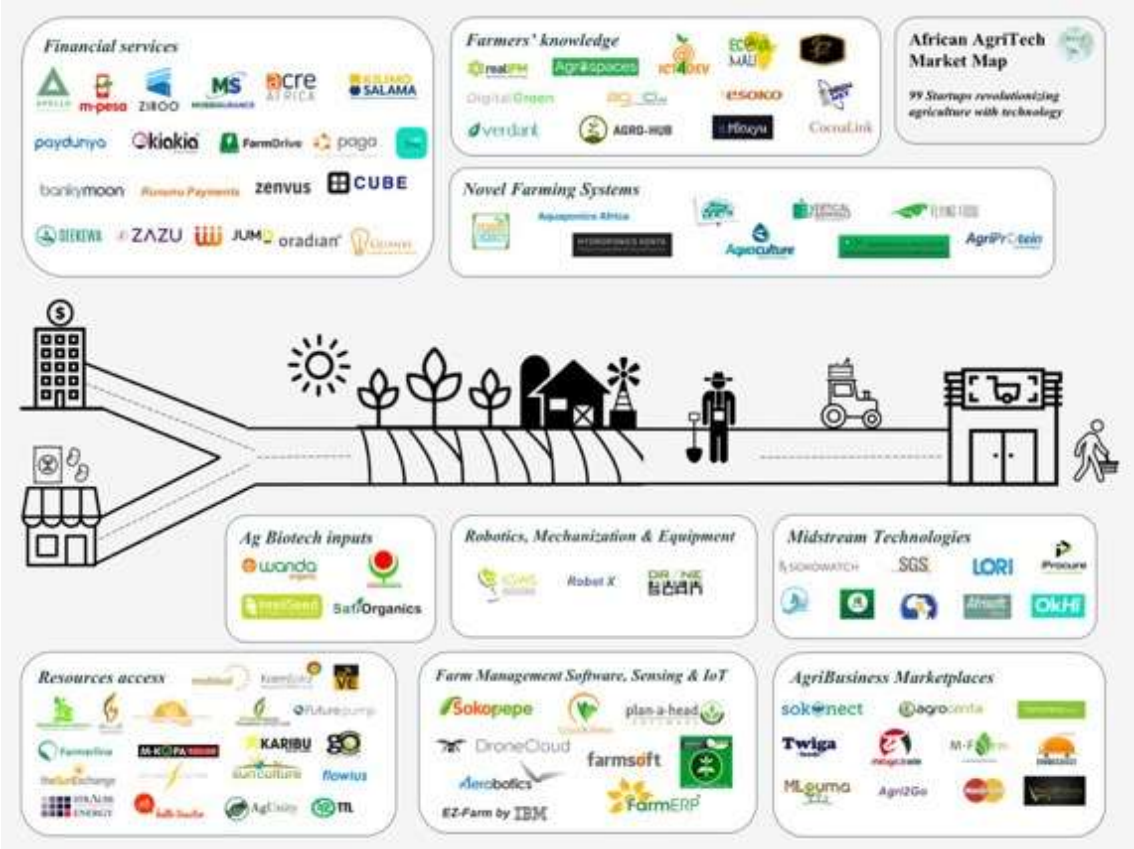

Figure 7: African Agtech market map. Startups in Africa that are playing an important role in agriculture.

Figure 7 shows the main agtech startups that are playing an important role in Africa countries.

Digital technology in Africa will give farmers access to the technology of modern agriculture, scaled down for small holders. The African challenge is to avoid scaling up farm size and improve their farm and family income from the land to improve their quality of life and to keep people in rural areas.

The following link is to a nice article that shows how inclusive and simple technology like SMS can help small farmers to achieve and use digital tools.
https://medium.com/@wizaj/how-a-20-year-old-mobile-technology-protocol-is-revolutionising-africa-with-numbers-744a52cbea92

Israel

Israel breathes innovation by necessity. As a small country, Israel needs to export their production to support their citizens. When the country was created, they established the Kibbutz system for Israeli people to live and work together to produce and export fruits. As the production sector mechanized, the demand for labour in the Kibbutz's decreased, so Israel started to export the technology developed by their bright and well-focused minds, such as agricultural irrigation, technology inputs and agriculture services.

Young entrepreneurs from Israel are stimulated to build their companies to solve world problems and not just local problems. Israeli companies are particularly making their mark worldwide in intensive crops and horticulture.

There are now more than 400 Israeli agtech startups working on innovations for the global agriculture sector, according to new research from Start-Up Nation Central, an Israeli NGO and Greensoil Investments, a local agtech venture capital firm. Start-Up Nation Central is a virtual connectivity hub where startups openly present their businesses and anyone in the world can connect with them.

Figure 8 shows the multitude of agtech firms involved in Israeli agriculture in the follow main areas:

• **Biotech** – Typically involves breeding of plants and bacteria with improved traits to help plant growth. Some companies use genetic technologies for that. These include companies such as Groundwork BioAg, Rootility, and Kaiima.

• **Smart farming** – Data-based technologies making use of big data and predictive analytics to help farmers make better decisions on daily farm issues (irrigation, pest management, risk management, etc). Some of the better known companies are Taranis, Phythech,Cropx, and Prospera

• **Crop protection** – Biological or chemical substances used for protecting the crops from pests & diseases, nontoxic and environmentally friendly. Companies like Biofeed which produce a product which lures insects away from crops, or EdenShield**.**

• **Machinery and Robotics** – Companies that build all kinds of robotics, machinery, and equipment used primarily to automate farm work, harvest crops and to sort it. Metomotion is one example with a robotic system developed for greenhouses.

• **Irrigation & water management** – Israel is well known for water innovation, but there are new companies that are creating innovative irrigation methods which improve water efficiency, such as Neotop which covers water reservoirs and Emefcy which created an energy-efficient wastewater treatment.

• **Post-harvest** – Technologies to reduce post-harvest losses in diverse ways (e.g. storage, packaging, treatments and climate management technologies). An example for these companies can be found in Amaizz which deals with drying produce or Valentis Nanotech,which produces polymeric films for coating greenhouses.

• **Farm to consumer** – Companies that leverage new business models to shorten and simplify the supply chain by connecting the farm to the end consumer. This is usually done through digital platforms. A good example would be Avenews-GT, which builds a digital trading platform connecting food wholesalers with producers.

• **Novel farming systems** – Innovative systems for growing plants, new types of greenhouses, urban farming, hydroponics, and aquaponics. It could be small scale growing in the case of Flux or lighting solutions for farmers such as FloraFotonica.

• **Livestock** – Companies that create technology for farm animals and pets. With mass vaccination companies such as ADST Technologies and Eggxyt's pre-hatch sex detection for chicks

• **Waste technologies** – Processing livestock manure, fertilizer run-off, harvest, and food waste to reduce harmful substances and reuse the materials. Companies

like 3PLW and HomeBiogas which convert organic waste to bioplastic and cooking gas, respectively.

• **Special crops** – Companies which deal with medicinal plants from growing human tissue repair implants, such as Collplant, to cannabis-based products, in the case of Corsica Innovations

• **Aquaculture** – These are companies that develop technologies to grow things in water – algae (e.g., Algalo), fish or sea food (e.g., BioFishency)

Figure 8: Greesoil investments - Israelli Agtech Startups

https://agfundernews.com/israels-agritech-market-map-400-startups-putting-the-tech-in-agritech.html

India

An estimated 450 million people, which equates to 34% of India's population, depend on farming for their livelihood. An interesting phenomenon of Indian agriculture is that it is increasingly feminized, with more and more women working in the fields while menfolk migrate to urban areas seeking alternate employment. Despite the increasing contribution by women to farming, few women hold titles to the agricultural land in their name.

Landholdings are small and getting smaller. The average size of farmland holdings in India is falling, on account of the division of landholdings among siblings in each generation. Average holdings are currently around 1.2 hectares (3 acres) and widely expected to drop to one hectare or less. In fact, nearly 50% of Indian farmers have land holdings of less than half a hectare already.

With this reality, the farmer has limited ownership of modern farming assets, such as machinery. The penetration of tractors in India remains well below 10% — by comparison, the adoption of mobile telephones has surpassed 50%. This creates a big opportunity for ag-tech entrepreneurs to act, especially given the high level of digital resources such as coding capability in India, compared to African countries where digital solution capability is generally poorly developed.

Figure 9: Visiting a hub for organic food promoted by an IT entrepreneur in India.

Five agtech innovations that have the potential to collectively and comprehensively create digital solutions are:

1. **Farming-as-a-service** to make costs variable and make farming affordable to the majority of small and marginal farmers.
2. **Big data intervention** through real-time capture and synthesis of data to aid farmers in better decision making.

3. **Market linkages** for the sale of farm produce to facilitate dis-intermediation and aggregation of farm produce, so farmers reap a higher share of the end-consumer price.
4. **Fintech platforms**, to aid institutional financing to reduce the cost of borrowing for farmers.
5. **Diversification** to increase the sources of income for farmers

Incubators and programs:

1. **Rural Incubation Centres:** The Government of India entrepreneurship fostering initiative, Atal Innovation Mission, will provide grants of up to Rs100 million ($1.5 million) to each centre, with preference given to incubator centres set up in rural areas, which target agriculture innovation.

2. **Rural Entrepreneurship:** Agriculture alone cannot provide a sustainable living for India's teeming rural youth. Rural youth will not be tempted to migrate to urban areas for employment if they are provided with entrepreneurial opportunities in the villages. These opportunities can centre around services that are in high demand, such as value-adding, farm produce storage, soil scanning, renting equipment and cattle feed centres.

3. **Village Data Hubs:** Farming decisions are based on previous years' data, as the availability of real-time and accurate current-year data is limited. Institutionalizing farm advisory services through village data hubs will help capture real-time data from in-field interventions such as drones, sensors, IoT and satellite images, with access to this on smart phones, which are today affordable. Innovations should drive real-time capture and analysis of the data and the disaggregation of data at the farm level.

4. **Village Adoption by Research Institutions:** Simple mechanisms to transfer technology from research institutions and agricultural universities to farmers; and incentives for institutions to adopt clusters of villages to facilitate "faculty-researcher-student-farmer" interaction, will provide much-needed support to the farming community. The village adoption program of the National Institute of Food Technology, Entrepreneurship and Management (NIFTEM) in India, trains farmers in food technology innovations.

United States of America – USA

Beyond traditional places like Silicon Valley or New York, there is evidence in the USA of a positive movement to Agtech and the emergence of mini-clusters and new fund investors in regions like Iowa, Missouri and Tennessee, while an increasing number of international startups seek a beachhead in the US. These clusters attract a new generation of farmer entrepreneurs or young people more connected to farmers than traditional tech entrepreneurs.

As the biggest and most dynamic market for Agtech startups, the USA already has the firsts unicorns (startups that achieve more than $1 billion in valuation) in agriculture.

The following link describes an interesting list of Forbes 25 most promising Agtech startups from 2018:
https://www.forbes.com/sites/maggiemcgrath/2018/06/27/the-25-most-innovative-agtech-startups-in-2018/#5066ede52302.

Incubators and programs:

TERRA is a food and agtech accelerator, founded by Rabobank and RocketSpace. It combines Rabobank's food and agribusiness leadership and expertise with RocketSpace's global tech ecosystem. Collaborators include Nestle, AgroFresh, Griffith foods and GrainCrop among others. Its headquarters is in San Francisco, California. Terra accelerates Agtech companies and helps them build a high impact business model that limproves company growth.

Plug and play (PNP) is a food innovation platform, based in Silicon Valley, California. This accelerator is focused on solving the global drought problem through innovations. PNP brings together startups, venture capital and corporations from around the globe to participate in growing the food, agriculture and beverage sector. Partners include Hershey's, Panasonic, PepsiCo, and Ajinomoto. Other than food and agtech, they participate in finance, Internet of things, travel and hospitality, insurance, health and wellness, among other topics.http://plugandplaytechcenter.com/food/

THRIVE is an accelerator which focusses on solving significant challenges facing the food and agriculture sector around the world. The 10-week program runs in Silicon and Salinas Valleys, California, once a year, comprising 10 to12 cohorts that train and stimulate young entrepreneurs to build impactful solutions and also connect them to the market and agriculture leaders . So far, 32 startups have benefitted from the program. Partners include Verizon, Land O'Lakes, Inc., Forbes, Thought for Food, and others. http://thriveagtech.com/

The Yield Lab - Louis, Missouri, The Yield Lab invests US$100,000 in technology startups that are revolutionizing agricultural and food systems to achieve sustainability. They have a program where startups meet six times a year, over a period of two to three days. These startups each get assigned a Yield Lab Managing Director and gain access to investments, customers, and partnerships.
https://www.theyieldlab.com/st-louis/

Western Growers – An innovation hub created in Salinas-CA to help member horticulture growers do more with less, The Center was created to help identify industry priorities, discover technologies to address those priorities, set up testing, facilitate industry feedback and communicate progress to California, Arizona and Colorado fresh produce farmers.
http://www.wginnovation.com/

FARM 2050- Innovation Endeavors and Flextronics' Lab IX founded Farm2050 with top industry players, in the belief that innovation and technology are critical to addressing the global food challenge. It offers exciting opportunities where entrepreneurs can apply cutting-edge technologies to improve food production today, and demonstrates how advances in data science & robotics now enable farmers to rethink the way they seed, cultivate, and harvest food. FARM 2050 teaches farmers to believe that innovation is fundamental to overcoming this challenge.
http://www.farm2050.com

FOOD-X - Food-X hosts innovative conferences and forums in the agriculture and food sector. They refer to themselves as the *"#1 food innovation accelerator in the world*". They are also an investment platform for interested individuals and companies. Selected startups are vetted to instill investor confidence. The startups will receive US$50,000 in funding and have a chance to access convertible loans during the 14-week program period. Other benefits include access to a network of world-class investors, entrepreneurs, press and experts in the food industry. Selected participants can also co-work with different groups since they have a shared space.
https://food-x.com/

The Kirchner Food Fellowship has partnered with The Hunger Solutions Institute Universities Fighting World Hunger, to create and fund the food program. Selected elite student leaders from top North American Universities get an opportunity to make business investment decisions for agriculturally oriented enterprises. The goal is to generate long-term sustainable solutions to growing global food insecurity issues.
http://fundthefood.com/

The Good Food Accelerator is specifically for startups based and operated in Chicago. Any interested startup must conform to the values held by the accelerator with regards to quality of food and practices used to produce it. Selected startups can enjoy benefits such as access to working space, public and private potential sources of funding, a mentoring program, potential consumers, and partnerships. Startups also get to pitch their innovations to farmers and investors during conferences. The accelerator has an interest in startups that focus on running a profitable good-food business. http://www.goodfoodaccelerator.org/about-the-accelerator/

Royse AgTech Innovation Network focuses on companies developing new technologies for the food and agriculture sector, and specifically production. It is based in Palo Alto, California. They help startups gain access to partners, markets, and funding. Selected startups have an opportunity to pitch and hold meetings with food and agriculture companies, farmers and investors. They also organize demonstration days for startups and Agtech conferences. http://royseagtech.com/

Chobani Food Incubator is both a food incubator and accelerator, based in New York. Startups receive a US$25,000 grant and access to working capital, equity free. They also participate in a six-month program, where they gain a working space, access to the community, mentors and networking opportunities. The company looks for purpose-driven startups doing the right thing and that are ready to take the next steps. https://www.chobanifoodincubator.com/

KitchenCRU Apart from being a community kitchen, this is a culinary incubator that aspires to help business within the sector to develop, grow, and operate. KitchenCRU gives startups access to fully equipped and operational working spaces. They provide support and offer business referrals for services such as legal, marketing, graphic design, banking, insurance and advertising. They are based in Portland, USA. http://www.kitchencru.biz/about/

Shoals Entrepreneurial Center is a business incubator focused on launching and helping startups grow. Startups will benefit from a shared working and kitchen space, equipment and access to resources such as a network of experts, partners, mentors, and funding, including Angels. Others include online and group marketing events. http://www.shoalsec.com/specialty-food-production/

Also in US they have a big number of Agtech startups that are playing important holes in agriculture and some of than have being both by big traditional agriculture companies such as:

Grannular, a startup that help farmers management their farms that have been acquire by Pioneer for more than 300 million US$.

BlueRiver Tech – A robotic startup that use AI in machines that have been acquired by John Deere for over 300 million US$.

Indigo, A biotech startup that rise more than 200 million and help famers adopt bio technologies to improve their crops.

Farmer Business Network – Set up by Google Venture, this company helps farmers benchmark their data, to make better decision in inputs, acquisition or marketing their production.

European Union

A driving production force since the Industrial Revolution, European countries have always been strong food producers and exporters. Countries like Germany, Netherlands, United Kingdom and France are top in the raking of food exporters. Startup activity in food and agriculture innovation is also growing. Since 2015, investment activity has increased, as government and EU agriculture programs have focused support resources towards food and agtech startups and agri-innovation. European startups tend to focus on farm-to-table solutions, crop management tools, solutions that solve problems linked to environmental issues and the efficient use of agri-inputs.

Incubators and Accelerator Models

Kickstart Accelerator. Based in Zurich, Switzerland, with some of its branches in Basel, Kickstart is one of Europe's multi-corporate accelerators. They accept startup applications, not just from Switzerland but also from around the world. The startups they work with cut across a number of industries, the main six approach's being Food, Robotics & Smart Systems, FinTech, Healthcare, Smart Cities, EdTech and Agtech. https://kickstart-accelerator.com/

Startupbootcamp (SBC) is a global network of accelerators focused in different industries that include Foodtech, Smart Cities, Digital Health, CyberSecurity and Smart Energy among others. Foodtech is specific to Rome, Italy and Eindhoven, Netherlands. However, startups from other countries can also apply. They have a three-month program where the selected startups are assisted with guidance from first-class investors, entrepreneurs and partners.
https://www.startupbootcamp.org/accelerator/

SeedRocket :This accelerator has attracted successful professionals from different sectors of the digital world. Based in Barcelona, SeedRocket provides mentoring and support by investing in startups that show potential for high growth. They select teams of 10-12 individuals for a one-week program where they receive training from mentors. At the end of the week, their projects are handed to various stakeholders for assessment, where they stand a chance of winning a US$180,000 in seed funding.
http://www.seedrocket.com/2018/01/31/en-busca-del-exito-inscribe-tu-startup-en-el-xix-campus-de-emprendedores/

Eleven - This Bulgaria-based capital venture fund and accelerator is available to early startups, providing infrastructure, technical resources, mentoring and support and a first round of investment for over 50 selected companies. The investment comes as a consecutive double three-month program for an equity stake of 8%. Being one the largest investors in Bulgaria, they have partnered with IBM, Microsoft, Google Amazon Telerik and TechStars to deliver technological solutions and infrastructure. https://www.11.me/

HappyFarm - This is a Ukraine-based business accelerator that provides business development services to startups and investments wanting further support. It has a team of international mentors from various business and IT-oriented sectors. The main purpose of this accelerator program is to commercialize new technologies and developments in the IT sector. The program starts by selecting 10 startups for a one-

month internship program, and links with potential partners and investors to boost the growth of their businesses. http://happyfarm.com.ua/

INiTS is a top European and globally ranked university business incubator, according to the Swedish Research Initiative UBI Index. Since 2002, over 180 startups have benefitted from INiTS, with many still in the incubation stage, while others have achieved alumni status. INiTS offers support to various industries including agriculture, food technology, and life sciences. Based in Vienna, Austria, INiTS is part of the Ministry of Infrastructure program, AplusB. It is a company co-owned by University of Vienna, the Vienna Business Agency, and the Technical University of Vienna. They have an extensive 18-month long incubation program offering startups, mentoring, hands-on support and infrastructure such as workspace, funding and access to a network of experts, investors, researchers, and entrepreneurs. All these services are meant to assist startups to grow their innovative ideas and market them. http://www.inits.at/en/

AgFunder offers a marketplace for promising agriculture and agtech startups seeking to raise investment capital from an accredited investor. It provides a platform for investors with interests in agriculture, food, and agtech to connect with startups that have been approved through the AgFunder in its due diligence process. As well as offering funding, startups also get exposure to industry clientele, executives, professionals, and partners. The online platform enables a worldwide reach. https://agfunder.com/

Beta-i has been identified as one of the biggest non-profit innovation hubs and entrepreneurship organizations in Europe by the European Enterprise Promotion Awards in 2014. It also received recognition from Wired magazine as *"the top incubator in town*" in 2016. Based in Lisbon in Portugal, Beta-i offers assistance to new and established businesses. They have received over 4,000 applications from over 60 countries since inception and have worked with over 600 startups. Beta-i offers funding and conducive work spaces, as well as organizing community events and investment summits such as Lisbon Investment Summit. http://beta-i.com/

Nestlé, Rabobank, and Unilever all have platforms to stay on top of emerging startups and technologies in food and agriculture. Many corporates like these have quickly and widely picked up foodtech and agtech as a strategic priority and there is a growing range of resources for startups from venture capital funds to incubator initiatives. Corporates are also getting involved in externally organized and managed initiatives like the European FoodNexus Startup Challenge, which aims to identify and accelerate leading food and agtech startups by connecting them to corporate partners, including Unilever, Nutreco and FrieslandCampina.

The Horizon2020 **program** is an $80 billion European Union public fund used to stimulate early-stage research and innovation across sectors and bring new technologies to market across Europe. The program requires the public sector and the industry, including startups, to work together in delivering innovation. One example is Dutch Startupdelta whose focus is to position Europe as a single market for startups and scaleups, by removing barriers to international expansion and linking Europe to the rest of the world.

What is needed to take agtech forward?

To bridge the gaps between research and commercial companies in food and agriculture, significant expertise may be necessary. In particular, this is a challenge for upstream subsectors, such as agricultural production, given the complexity of the natural, technical, and social systems involved. Though many resources currently seek to support ventures in this space, there are still a few critical gaps.

For example:

- Lack of focus on small, but important, niche areas such as row crop commodity production, small holders and soil health.
- Lack of grower engagement across most of the resources in the landscape. The innovation hubs are often full of young, technologically oriented people, and in many cases are missing a genuine connection with farmers and farming realities.
- Lack of physical infrastructure, such as lab space and in-field pilots. Unfortunately, even many of the most successful agriculture ventures are having difficulty achieving deep market penetration. Farmers may be using AgTech products, but unfortunately these products have failed to demonstrate sufficient value to attract paying customers on a large scale. Today most of the agtech startups are limited to early adopters: to achieve more scale, these need to connect with high-value niches, farmers and relevant infrastructure so they can test their products in real conditions.
- Lack of support, technical assistance and capital - particularly for on-farm agriculture. Much of the funding is currently allocated to downstream subsectors such as foodtech and e-commerce. Although the industry is beginning to acknowledge this gap and slowly changing, a huge opportunity exists to connect to the agtech landscape by providing more domain-specific support for AgTech ventures.
- Increasing farmer age – In USA, there are three times as many farmers over 65 years than under 35. Farmers need to be tech capable and have access to IT skills and this age differential may slow down the rate of adoption in most countries.
- Finally, it is also worth raising the question of whether it is most effective to provide financial resources or technical and knowledge resources. In cases of agriculture startups, sometimes on-the-ground experience can have more value and save more time and money than a traditional startup accelerator program, and farmers' accumulated experience can be an invaluable resource for startups and entrepreneurs.

Conclusion

The digital revolution is coming to agriculture and will change the sector to a similar extent that Amazon, Google and Apple have changed the game for shopping, research and digital tools. Given the complexity and fragmentation of the agriculture landscape, changes will probably be more step-by-step than in more consolidated sectors. The biggest challenge and opportunity is to use this revolution to address the Sustainable Development Goals (SDG) and in particular he first goal of No Poverty and the second goal of Zero Hunger so that ***no-one is left behind*****.**

The near future has drones spraying plague infestation in a $10m^2$ plot in Brazil, robots harvesting avocados in Israel and farmers in India selling and buying from their smartphones. However, broad adoption of these changes takes time and requires capable people to teach farmers how to use this technology. Agronomic extension services are fundamental in ensuring that **no-one is left behind**.

Farmers already weigh up a complex range of variables to make decisions and with this new wave of tools and technology, it is critically important that farmers have the capability and support so they can participate beyond the traditional realms of production to become key players in holistic business spaces such as information technology, traceability, finance sustainability and trade.

An Evergreen Revolution for Green and Lean Agriculture

The task of sustainably increasing global food production is one of the monumental challenges of our time. The framework of the “Green Revolution” is helpful in reminding us that, while technology has worked to produce more food in the past, we now must produce more food while also eliminating agriculture’s negative environmental footprint. A successful Evergreen Revolution will require many players, but in particular, it will require entrepreneurs who are passionate about promoting innovation and investment in agtech. In short, our overall objectives should be to:

- Increase awareness so that more entrepreneurs and investors can seize this opportunity while helping meet this most basic societal need.

- Foster vital communities of agtech activity across the world focused on a “Lean and Green” theme, based on unique assets and the core competency of each region.

- Enable strong networks across communities, so that ideas and solutions can flow seamlessly for the benefit of all.

- Develop strong educational pillars so that talent and skills are up to par with the challenge at hand.

- Connect the old experience with the new. Promote, difference, common purposes and connection of city people (consumers) with farmers (producers). Stimulate their interaction to solve common problems

Three significant growth opportunities are available for current and future players looking to seize opportunities from the changing agricultural ecosystem:

1. Improving yield efficiency - the world population, of which 10% remain undernourished, is rapidly growing, thereby creating a severe urgency to increase yields. For farmers, increasing yield without planning or adding value can be a trap for economic sustainability. Yield increases need to come with value-adding in agriculture products.
2. Increasing supply-chain efficiency - reducing the average value-chain loss of 33% of initial production is a substantially stronger lever for increasing effective output than upfront yield improvement. Improving traceability through the likes of blockchain technology and connecting farm-to-table can be part of the solution.
3. Decreasing the complexity along the farmers' value chain - since today's farmer already face high complexity and tomorrow's farmer will deal with even more players and technologies, more farmers should be willing to pay for integrated solutions and ecosystems. Technical assistance and knowledge sharing will be the key to face this challenge.

Recommendations

What farmers can do to be part of the digital revolution

For farmers to genuinely participate in the digital revolution in a way that ensures that no-one gets left behind, the following recommendations are proposed:

1. **Educate and promote the need and opportunity for AgTech and sustainable agriculture** so entrepreneurs will build agtech companies, so investors will direct capital to agtech ventures and so public officials will promote agtech development through public policy. Farmers play a key role in identifying the key problems that need solving within the farm gate and along the food chain.
2. **Investment needs to focus on bringing real solutions to real problems.** Connection is the key to promote the union between farmers and Agtech entrepreneurs.

3. **Build and support regional AgTech entrepreneur support systems with "agri-preneur" leaders.** Social relationships and a collaborative culture are incredibly important elements on which to build an effective entrepreneur support system. The support system should be led by an agtech entrepreneurial leader, who is thoroughly conversant with the agricultural ecosystem and has

deep expertise in the area of entrepreneurial activity. Furthermore, these leaders must be willing to set aside his or her ego and let others take credit. Such a selfless leader will create a collaborative, grassroots entrepreneurial culture, which will mature in quality and volume to establish as scalable culture with many investment opportunities.

4. **Regional agripreneur champions should be consciously stimulating,** in order to enhance the overall network and share ideas about how individual regions are developing and supporting entrepreneurs. As the collective support systems gain momentum, entrepreneurial activity and needed innovations will blossom. Thus, agripreneurs will attract and develop more agripreneurs.

5. **Enable the transition to new technology around the theme of "Green and Lean Efficiency."** We are shifting from scale-driven efficiency of the Green Revolution to a "green and lean" efficiency. After sixty years of chemical control, farming now is entering an era of responsible, transparent, and ecological control, driven in part by consumer demand. Agtech is at the cusp of a new revolution in which innovations in seeds, nutrition, protection, and agronomics are merging. Experts have pointed to similarities with the IT field, in which leading players have embraced convergence and interdependence in internet search, cloud storage, smartphones, tablets, and PCs, while still carving out their own space to effectively compete. Agtech must go through a similar revolution where diverse players will unite to drive state-of-the-art developments in crop nutrition, crop protection, biotechnology, and agronomics and create integrated agricultural productivity.

6. **Engage nonpartisan groups in hubs of Agri-innovation.** Independent, nonpartisan organizations have the unique ability to bring like-minded people and those with divergent views to the table. Having these take up the cause will help further the common goal of providing nutritious food to a growing population in an environmentally sustainable way. These Agri-innovation hubs will be key in connecting agtech best practices to farming communities worldwide by fostering networks in which knowledge is shared across communities. The challenge for public policy and investment is to provide an enabling space that support leaders and innovation rather than stifling or controlling it.

7. **Develop human and social capital to meet the needs of tomorrow**
   Human capital can be defined as individuals having the skills, knowledge and motivation required to contribute to an identified task. While the Evergreen Revolution has a diverse and new demand for another level of human capital, the new world where no-one is left behind calls for the building of social capital where trust, collaboration and synergy are the currency.

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Plain English Compendium Summary

Agriculture and Innovation:

What farmers can do to participate in the digital revolution

Nuffield Australia Project No.:

Scholar: Murilo Martins Ferreira Bettarello

Organisation: IZagro www.izagro.com.br) ViaVerde Tropical Agriculture Advisory Company

www.viaverde.agr.br

Av São Vicente, 5052 – Franca/SP – Brazil – CEP: 14403-830

Phone: +55 16 981320051

Fax:

Email: murilo@izagro.com.br / mbettarello@viaverde.agr.br

Objectives

Farmers are innovative risk takers, but they usually do not think globally to solve their costumer's issues, This report stimulates farmers to be part of the digital innovation in agriculture and not just users or passengers of this revolution. The goal is to push farmers to participate in the new digital trends and also take up the opportunities that this movement will present.

Background

This project is based on the experience gained from the move from being a field extension agronomist to building an Agtech startup.

Outcomes

Show farmers and Agtech entrepreneurs that connection and collaboration between them can create benefits and save time and money for both sides and build great solutions for the future for agriculture.