THE WORLD BANK
IBRD • IDA

Food and Agriculture Organization of the United Nations

Alliance
Bioversity International
CIAT
International Center for Tropical Agriculture
Since 1967 Science to cultivate change

CGIAR
Platform for Big Data in Agriculture

Digital Agriculture Profile • Argentina

©Brad Knox

HIGHLIGHTS

Abundant, fertile land and ample water resources have positioned Argentina among the top countries in the world for the production and export of key agricultural commodities. **Among other things, Argentina is the largest global exporter of soybean oil (US$3.88B)** and the second largest exporter of maize in Latin America.

Despite its high potential, **Argentine agriculture faces multiple concurrent challenges,** including an unstable policy environment, environmental degradation of natural resources exacerbated by climate variability, and economic and spatial inequities in productivity.

The role of digital solutions in the agricultural sector has increased in recent years, thanks in part to the enabling environment fostered by the Entrepreneur's Law.[1]

At least 54 digital agriculture startups are currently operating and gaining traction in Argentina's ag-tech sector, including agriculture biotech, agribusiness marketplaces, farm management software, remote sensing and IoT[2], and novel farming systems.[3]

THE AGRI-FOOD INDUSTRY CONTRIBUTES TO TWO OUT OF 10 PRIVATE JOBS, AND **22%** OF NATIONAL EMPLOYMENT

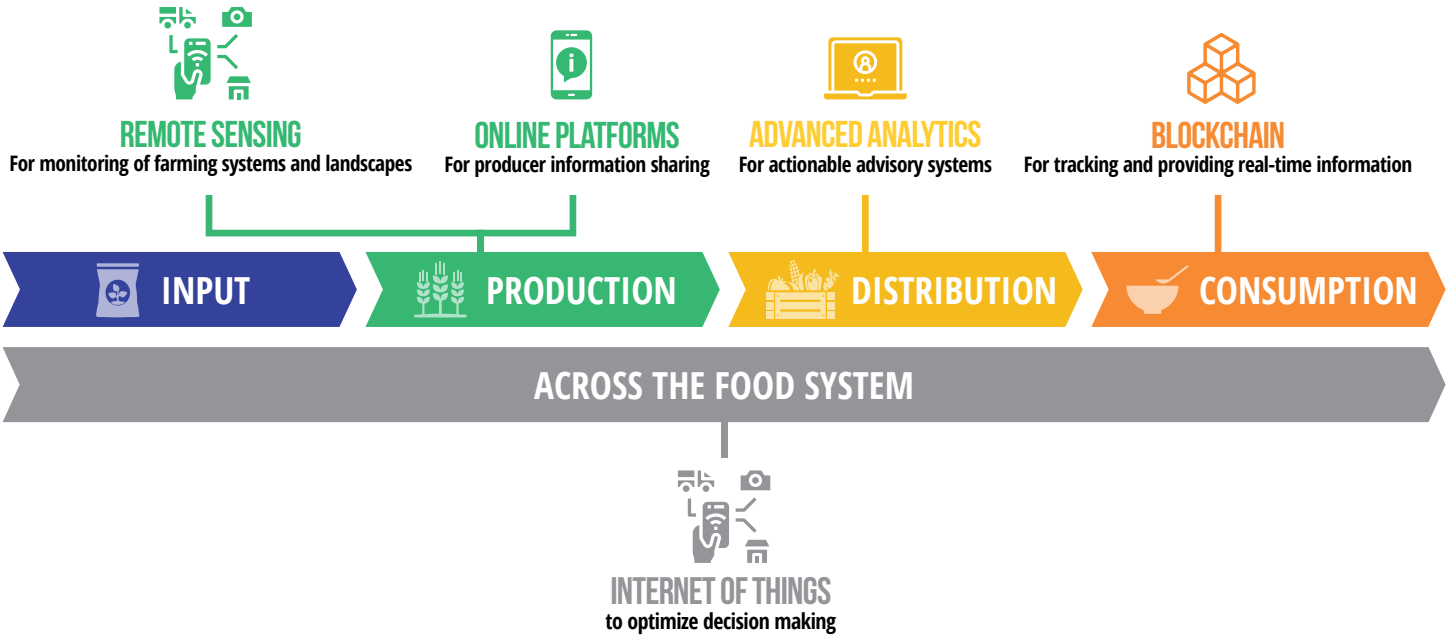
THE LITERACY RATE FOR PEOPLE 15 AND OLDER IS AT **99.4%**

OF THE 223,292 PRODUCERS IN ARGENTINA, **21%** ARE WOMEN

LARGE-SCALE FARMS, AVERAGING ABOUT 1,500 HECTARES, OCCUPY **78%** OF TOTAL AGRICULTURAL LAND

1 Ministerio de Producción y Trabajo, "Todo sobre la Ley de Emprendedores".
2 Internet of things.
3 Club AgTech, "Balance del mercado Agtech 2018."

PRIORITY TECH SOLUTIONS



Introduction

Argentina's vast farmland and favorable natural conditions have placed the country among the world's leading agri-food producers and exporters. Its agricultural sector is dualistic in nature. In the Pampas region, the sector is comprised of commercialized grain and oilseed production. Here, extensive farming and the use of mechanization, innovation, and technology dominate agricultural production.[4] Production of higher-value crops, such as fruits, vegetables, and legumes, is less commercialized and predominantly takes place outside the Pampas region.[5] Production of high-value and industrial crops still lacks the contemporary technologies and decision-support tools needed to maintain and improve yields.

Despite its high potential, Argentine agriculture faces multiple concurrent challenges, including climate variability, environmental degradation, and economic and spatial inequities in productivity. With recent changes in public policies, Argentina has developed a support system for agricultural innovation and entrepreneurship aimed at addressing these challenges. Nevertheless, public investments outside the Pampas region remain insufficient to drive changes in R&D,[6] extension services, and the technical assistance needed to support the sector, otherwise creating risks of further regional inequities. Digital agriculture is in a position to address some of these challenges.

Digital agriculture is defined as a suite of tools that collect, store, analyze, and share digital information along the entire food value chain, from farm to fork. It encompasses the linkages of a diversifying and rapidly expanding spectrum of digital technologies across various value chain segments. It is anchored in data generation and data systems. Integrating digital solutions into agriculture has the potential to increase technical and allocative efficiency on-farm by (1) improving the use of capital, such as machinery and equipment; (2) improving labor efficiency and the optimal use of inputs by facilitating the acquisition of skills and knowledge necessary for agricultural production; (3) improving on-farm decision-making through the collection, processing, and wide dissemination of precise, timely, and geo-spatially tailored data on agronomic, weather, and price information; and (4) reducing the costs of linking

4 OECD, "Agricultural Policies in Argentina.

5 OECD, "Agricultural Policies in Argentina.

6 Research and development.

SOYBEAN OIL
IS ARGENTINA'S LARGEST EXPORTED COMMODITY
(US$3.88B 2019 EST.)

ARGENTINA IS RANKED AS
THIRD LARGEST EXPORTER OF SOYBEAN GRAIN GLOBALLY
AFTER BRAZIL AND UNITED STATES OF AMERICA

MAIZE IS THE COUNTRY'S SECOND LARGEST EXPORT
US$4.05B

ARGENTINA IS THE
SECOND LARGEST EXPORTER OF MAIZE IN LATIN AMERICA

producers and consumers across the different value chain segments, thereby significantly lowering transition costs and optimizing the matching process in agricultural markets. Digital agriculture presents a unique opportunity to spur sustainable economic growth and development by addressing challenges facing Argentina's agriculture.

As part of the World Bank study "What's Cooking: Digital Transformation of the AgriFood System," this Digital Agriculture Profile for Argentina leverages the expertise of stakeholders to evaluate the current landscape of digital agriculture in Argentina, taking into account its key actors across value chains, the main challenges they face, and the potential to overcome these barriers through the adoption of innovative digital technologies. Mainstreaming digital agriculture will require further analysis of enabling factors, but identifying and prioritizing digital technologies allows donors, governments, investors, and other stakeholders to focus on the technologies with the highest potential in order to maximally improve food production in Argentina.

Natural Context

Economic relevance of agriculture

Abundant, fertile land and ample water resources have positioned Argentina among the top countries in the world for the production and export of key agricultural commodities as well as development of a strong agro-industrial complex. Soybean oil is Argentina's largest exported commodity (US$3.88B, 2019 est.), and Argentina is ranked as the third largest exporter of soybean grain globally, after Brazil and the United States of America. Maize is the country's second largest export (US$4.05B); Argentina is the second largest exporter of maize in Latin America.

In 2016, primary agricultural production represented 8% of the GDP,[7] while the whole agro-industrial transformation sector was estimated at 32% of GDP.[8] Furthermore, the agri-food industry contributes to two out of 10 private jobs, and 22% of national employment. Due to the agri-food sector's large share of the economy in general, and particularly the export market (64% in 2016), developments in this sector have ramifications for the entire national economy.

Agricultural production systems

Argentina's landscape is varied, from snowy Patagonian mountains to rainforests. In the last 25 years, agricultural land has expanded from over 15 million hectares to 34 million hectares, a more than 126% increase in total land devoted to agriculture.[9] Soybean and maize production are the main commodities produced in the country; their production occupies more than 50% of the total agricultural land. Beef has historically been a valuable commodity, but in recent years its production growth has not kept pace with poultry and pork products.[10] In 2018, Argentina produced 109 million tons of grains; 5.7 million tons of meat (poultry, beef, and pork); 10,526 million liters of milk; 1,452 million liters of wine; and other agricultural products, including legumes, fruits, and vegetables.[11]

The most important agricultural zone of the country is the Pampas region, which includes the primary economic provinces: Buenos Aires, Córdoba, and Santa Fe. Most

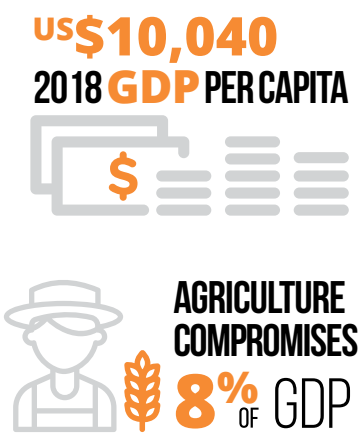
7 Gross Domestic Product.

8 Regúnaga, M. and A. Tejeda Rodriguez (2015), Argentina's agricultural policies, trade and sustainable development objectives, International Center for Trade and Sustainable Development (ICTSD).

9 United Nations, "Argentina."

10 OECD Food and Agricultural Reviews, "Agricultural Policies in Argentina."

11 FADA, "El Campo Argentino en Números."



of Argentina's extensive export crops—grains, oil seeds, and livestock—are produced here. Large farms in the Pampas region are characterized by extensive farming and the implementation of mechanization and modern technologies. In 2018 alone, INDEC reported 15,947 units of agricultural machinery sold, worth a total of US$1.097 billion.[12] Innovation in the Pampas region, incorporating technologies such as improved seeds, fertilizers, and new digital solutions, has been widely incorporated into on-farm practices.

The main producers of intensive crops, such as horticulture products, are primarily located outside the Pampas region. They produce approximately nine million tons of fruits, legumes, and vegetables per year.

People, livelihoods and agriculture

Only 0.4% of the Argentine population lives below the international poverty line of US$1.90 per day.[13] The Human Development Index ranks Argentina 47th in the world at 0.8 ("very high human development"),[14] and the Gender Development Index ranks Argentina 47th with a score of 0.99.[15] Approximately 8% of Argentina's population (about 3.6 million people) live in rural areas.[16] The rural population has a high level of access to electricity (99.9%) and to potable water (97.5%). [17]

The literacy rate for people 15 and older is at 99.4%.[18] About 80% of farmers in the Pampas region have completed secondary studies, 37% have obtained a university degree, and 8% have completed postgraduate studies.[19] A large proportion of those with university and postgraduate degrees (47%) are under 35 years old. According to the 2010 census, more than half of the national population (53.3%) reported using computers. The young average age of farmers in the Pampas region and their high level of education has facilitated the adoption of digital agriculture technologies in Argentina.[20]

The distribution of farmland is highly unequal across different types of farms. Large-scale farms, averaging about 1,500 hectares, occupy 78% of total agricultural land. Small-scale farms average around 150 hectares, and medium-scale around 500 hectares.[21] Of the 223,292 producers in Argentina, 21% are women and 16% are under 40 years old.

Challenges in the agricultural sector

Argentine agriculture faces various policy-related, economic, and environmental challenges. Despite a decade of high international commodity prices, agricultural and agribusiness investments fell from 2002 to 2013 as a result of various cyclical trade policy effects. Unlike almost all other OECD[22] members, Argentina's government support of producers is negative. This implies a heavy price burden on producers, who technically pay for transfers to first-line consumers and other actors in the value chain rather than being paid for the same. This negative support is generally caused by distortionary taxes on agricultural export products such as soybeans, beef, maize, wheat, and sunflowers. Additionally, the entire agri-food value chain faces an uncertain macroeconomic environment: as of early 2020, the Argentine peso has lost two-thirds of its value since 2018; inflation hovers around 30%; and the economy has contracted by about 4% since 2015.[23]

National economic growth is dependent on agricultural export commodities that are increasingly subject to climate hazards.[24] Extreme climate events such as droughts and floods have had major impacts on agricultural productivity in recent years. From 2009 to 2018 the country faced more than 269 drought- or flood-related emergencies. Farmers suffered yield declines in soybeans (estimated at US$8.7

12 INDEC. Censo Nacional Agropecuario 2018. Resultados preliminares.

13 The World Bank, "Poverty Rates | Argentina."

14 United Nations Development Programme, "Human Development Index."

15 United Nations Development Programme, "Human Development Index."

16 UNDESA, "World Population Prospects"; World Bank, "Total Population: Argentina."

17 World Bank, "Socio-Economic Sustainability"; Food and Agriculture Organization of the United Nations, "FAOSTAT."

18 World Bank, "Literacy rate, youth total (% of people ages 15-24) – Argentina."

19 Feeney et al., "Encuesta sobre las necesidades del productor agropecuario argentino."

20 OECD, "Agricultural Policies in Argentina."

21 CIAT, Julián Balduncie, farmer, entrepreneur, agtech investor, and founder of Acronex.

22 Organisation for Economic Co-operation and Development.

23 OECD Food and Agricultural Reviews, "Agricultural Policies in Argentina."

24 World Bank, "Agriculture Risk Management Policy Note for Argentina."

APPROXIMATELY **8%** OF ARGENTINA'S **3.6 MILLION PEOPLE** LIVE IN RURAL AREAS

ONLY **0.4%** OF THE ARGENTINE POPULATION LIVES BELOW THE INTERNATIONAL POVERTY LINE OF **US$1.90**

LARGE-SCALE FARMS, AVERAGING ABOUT 1,500 HECTARES, OCCUPY **78%** OF TOTAL AGRICULTURAL LAND

80% OF PAMPAS FARMERS HAVE COMPLETED SECONDARY STUDIES

37% HAVE OBTAINED A UNIVERSITY DEGREE, AND

8% HAVE COMPLETED POSTGRADUATE STUDIES

ARGENTINA RANKS **47TH** IN THE WORLD ON BOTH THE HUMAN DEVELOPMENT AND THE GENDER INEQUITY INDICES

billion), maize (US$2 billion), wheat (US$860 million), and sunflowers (US$8.7 billion) during this time.

Agricultural resources in Argentina are significantly affected by the environmental degradation. In particular, the rapid expansion of intensive soybean production systems poses environmental challenges, such as increased deforestation, high and increasing use of pesticides, and soil erosion and degradation.[25] Forest loss in 2012 imposed high costs to the overall economy, estimated at 0.74% of GDP. Meanwhile, the annual cost of land degradation is estimated at 3.56% of GDP. Although the agricultural sector has begun to shift towards environmentally sustainable practices, the progress remains slow.

Finally, Argentine agriculture is marked by productivity gaps across crops and regions. In the Pampas region, total factor productivity growth has been observed for the last two decades, driving the productivity growth in the sector. In contrast, total factor productivity outside the Pampas region has remained stagnant over the same period.

Current landscape of digital tools and policies

Digital infrastructure, availability and access

As of 2017, 74.29% of the Argentine population was using the Internet.[26] There are 140 pre- or post-paid mobile subscriptions per 100 people in Argentina.[27] 4G+ data speeds are widely available on all networks in and around Buenos Aires, with speeds decreasing at distances from the capital. At the same time, some rural areas do not have full mobile coverage. [28]

The ICT[29] Development Index ranked Argentina 51 worldwide in 2017 in terms of ICT accessibility, usability, and literacy.[30] According to the Telecommunication Infrastructure Index,[31] as of 2018 Argentina outranked the averages for global and regional readiness for ICT adoption.[32] The 2019 Global Connectivity Index, which measures ICT investment and maturity as well as digital economic performance, places Argentina at 48 of 79 countries with a score of 45. Notably,

25 Inta Balcarce, "Los suelos agrícolas de la región pampeana perdieron la mitad de sus nutrientes."

26 World Bank, "Individuals using the Internet (% of population) - Argentina."

27 International Telecommunication Union, "Global and Regional ICT Estimates."

28 nPerf, "2G / 3G / 4G Coverage in Argentina."

29 Information and Communications Technologies.

30 International Telecommunication Union, "Global ICT Development Index."

31 This index consists of the estimated number of internet users, the number of main fixed telephone lines, the number of mobile subscribers, the number of fixed internet subscriptions, and the number of fixed broadband facilities, each per 100 inhabitants.

32 United Nations I Department of Economic and Social Affairs, "2018 UN E-Government Survey."

Argentina's broadband penetration is the 3rd highest in Latin America.

Institutions and policies for Digital Agriculture

Argentine innovation, including the introduction of digital agriculture technologies, is mainly led by the private sector. Two significant private-sector initiatives headed by farmers' associations are the *Asociación Argentina de Grupos CREA* (AACREA) and *Asociación Argentina de Productores de Siembra Directa* (AAPRESID). AACREA focuses on providing effective technological solutions for specific problems through research and experimentation, as well as facilitating technology transfer, knowledge sharing, and experience sharing, both within and beyond its member group. AAPRESID focuses on the adoption of sustainable agricultural practices and the transfer of sustainable production technology. Both associations play an important role in promoting entrepreneurship and innovation by partnering with private and public organizations, e.g., the National Institute of Agricultural Technology (INTA), to complement their extension and technical assistance services.

Hundreds of accelerators have emerged within the private sector in recent years, and have been crucial in stimulating innovation and creating digital agriculture startups.[33] NXTP Labs, The Yield Lab, and Glocal Managers are well-known agtech-focused accelerators in Argentina; their role is to directly help innovative projects become profitable via services such as training and mentoring. Argentine banks and large companies easily identify investment opportunities within innovative projects through grant competitions and awards supported by private-sector actors.[34] An estimated US$1.7 million has been invested in digital agricultural companies to date from private-public partnerships.[35]

The public sector in Argentina plays an important role in creating basic and applied knowledge, facilitating its diffusion and adoption to all producers, and spurring innovation. The autonomous body for agricultural research and innovation in the country is INTA, which operates six research centers, 15 regional centers for research and extension, about 350 extension agencies, and 52 experimental stations throughout the country.[36] Over

AS OF 2017, THERE WERE **140** MOBILE SUBSCRIPTIONS PER 100 PEOPLE IN ARGENTINA

80% OF FARMERS USE BASIC DIGITAL TECHNOLOGIES SUCH AS FEATURE PHONES, SMS39, IVR40, AND 2G41 DATA CONNECTIONS

ARGENTINA'S BROADBAND PENETRATION IS THE **3RD** HIGHEST IN LATIN AMERICA

US$**1.7** million HAS BEEN INVESTED IN DIGITAL AGRICULTURAL TO DATE

AS OF 2018 ARGENTINA OUTRANKED THE AVERAGE GLOBAL AND REGIONAL TELECOMMUNICATION INFRASTRUCTURE INDEX SCORES FOR ICT READINESS

ARGENTINA RANKS **48**/79 COUNTRIES ON THE 2019 GLOBAL CONNECTIVITY INDEX WITH A SCORE OF 45

33 Trigo et al., "La Revolución Agrotech En Argentina: Financiamiento, Oportunidades y Desafíos."

34 OECD Food and Agricultural Reviews, "Agricultural Policies in Argentina."

35 Club AgTech, "Balance del Mercado AgTech 2018."

36 Instituto Nacional de Tecnología Agropecuaria, "Sobre el INTA."

the course of its existence, INTA has made significant contributions to agricultural technology, especially in crop breeding, soil management and fertilization, weed control methods, and adaptation to climate variability through its extension, information, and communication systems. It has also made substantial headway in the application of digital technologies in the sector, including web platforms, imagery processing, mobile applications, and virtual assistance services, with a focus on producers in the Pampas region.

The Argentine government has identified digital agriculture as a priority area for development and investment. As part of the Argentine National Development Plan, the Entrepreneur's Law was created to promote innovation and improve access to financing for the creation of new companies. Entrepreneurs can now create a company in one day through digitized services, as well as access finance and credit for early-stage projects. The Entrepreneur's Law has incentivized even more investment in accelerators and innovation hubs. In addition, the government also plans to invest an additional US$600 million in satellites to monitor natural disasters and soil moisture.[37]

End user diversity and demand

End users of digital agriculture solutions can generally be grouped by four hubs of the agri-food value chain: input, production, delivery, and consumption. Each hub has unique resources and needs in terms of digital agriculture innovations, and each hub faces unique challenges to which digital agriculture can offer solutions. These hubs are not mutually exclusive; any given individual may function within multiple end user hubs. Key experts in Argentine digital agriculture identified the users in each hub, their current and expected access, and the full spectrum of digital technologies appropriate for each via consultation and a facilitated workshop.

The **Input hub** includes all agricultural providers of seeds, animal feed, agrochemicals, machinery, finance, and other production inputs. Input and service suppliers play an important role in determining what technologies, products, and services agricultural producers will be able to access. End users in this hub seek access to decision-support tools that identify and select inputs to enable production in an environmentally sustainable way. This is especially true in soybean production, where intensification and high input use are of environmental concern. Input supplier companies are increasingly aware of the value of data generated through digital technologies, and are accordingly generating a huge amount of data that has proven useful in multinational settings.[26] Moreover, startups are playing a role in providing data analysis services for both large companies and individual farmers.[26]

The **Production hub** consists of agricultural producers. The consultation and workshop experts estimate that about 10% of Argentine large-scale farmers have access to advanced digital technologies, mostly related to remote sensing and machine learning, and the digital literacy skills to analyze datasets.[38] Importantly, these farms in Argentina occupy 78% of the agricultural land. Another 10% of Argentine farmers have medium-level access to digital technologies that are mainly related to financial and marketing application services and social media. The remaining 80% of farmers use basic digital technologies such as feature phones, SMS[39], IVR[40], and 2G[41] data connections.

The **Distribution hub** consists of all actors in the value chain between farmers and consumers, for example, traders, transporters, and processors. The workshop and consultation experts estimate that around 50% of distribution hub end users employ almost no digital technologies; this group is largely expected to begin using digital solutions in the near future.[30] Some 10% leverage advanced digital technologies, such as market platforms; these distributors often work with grains.[30] The remaining 40% of end users have medium-level access to digital technologies, such as market information.[30] In the highly developed Pampas value chains, the primary barrier for distributors is on-farm grain-storing capacity. For the less developed regional production systems, the bottlenecks are limited opportunities to sell to larger national markets and to maintain product traceability.

The **Consumer hub** consists of the consumers of both raw and processed agricultural products—in effect, the entire population. In Argentina, a majority of consumers do not use digital technologies to access market information.[30] Although a majority of the urban population uses email,

37 Squires, "Argentina bets on $600 million satellite to boost agriculture sector."

38 Center for International Agricultural Research, Argentina digital agriculture stakeholder workshop.

39 Short Messaging Service.

40 Interactive Voice Response.

41 Gigabyte.

social networks, and high-end smartphones, most individuals do not use these technologies to engage with the agricultural sector. The workshop and consultation experts estimate that approximately 30% of consumers in Argentina use digital technologies to track products, practices, and processes, and 5% use digital technologies to purchase agricultural products.[30] In general, the latter are seeking niche markets segments (e.g., organic or gourmet) that demand high product traceability. Key experts from the workshop and consultations predict a potential for up to 65% of consumers using digital technologies to purchase and/or trace agricultural products within five years.[30]

Digital agricultural services and applications available

Argentina is becoming a regional leader in digital agriculture startups and innovation. Currently, at least 54 digital agriculture startups are in operation and gaining traction throughout the Argentine digital agriculture ecosystem. These startups are involved in farm management and data analytics, agri-finance, tracking and tracing logistics, sensing and IoT[42], marketplace platforms, biotech, climate information services, irrigation systems and water management, novel farming systems, robotics, and image processing, among others.[43]

The case of Argentina demonstrates the importance of an enabling ecosystem in order for digital agricultural innovation to scale and support the growth of small-scale entrepreneurs. In most countries, digital agriculture entrepreneurs have a background in technology; in contrast, most digital agriculture entrepreneurs in Argentina have at least some experience in the agricultural sector.

The main categories of digital agricultural solutions that were identified in the workshop, along with examples of digital technologies that currently operate in Argentina, are as follows:

- Digital solutions to **monitor agricultural systems and landscapes** help determine optimal production management activities. For example, S4 AgTech[44] offers data collection, analytics, remote sensing, big data, and dashboard visualization solutions.
- Several Argentine private and public stakeholders have developed mobile-based **advisory and extension services** that generate and disseminate recommendations for end users based on data, images, and farmer queries. For instance, INTA has developed a virtual technical assistance service that leverages a network of experts to address farmer queries.[45]
- **Social network and discussion forum platforms** are widely used throughout the Argentine agricultural sector. La Rotonda facilitates supply and contracting of agricultural services such as labor and machinery.[46] Web platforms such as Agrofy assist in identifying products and services for farmers.[47] AAPRESID manages a webpage that lists all the digital solutions available in Argentina for producers. The MiLote application assists users in managing farm and production information across time.[48]
- There are fewer developments in the food system for **monitoring and traceability**. Existing initiatives, such as for sanitary requirements and quality assurance, monitor only portions of the chain. Some producers have recently begun including QR[49] codes, which link consumers to information about practices, products, and processes, on wheat flour bags. There are also currently some efforts to leverage blockchain technology for traceability.
- **Financial services**, such as online banking transfers, payments, and credit applications are well established in the Argentine agricultural sector.
- In large food processing facilities, **automation of processes and machinery** is also well established. Semi-automatic precision agriculture equipment uses AI[50] algorithms to perform soil preparation, fertilization, and harvesting for extensive crops in the Pampas region.
- Argentina is also well positioned in terms of **advanced data collection and processing**. For example, Taranis, an international precision agriculture enterprise, boasts the world's first high-precision aerial surveillance imagery system, which uses AI to identify potential crop issues.[51]

42 Internet of things.

43 Burwood- Taylor, "How Argentina is Creating an AgTech Startup Ecosystem."

44 Solapa S4 AgTech (https://s4AgTech.com/?lang=es).

45 INTA argentina, *INTA Agencia Virtual, Una Nueva Forma de Acercarnos.*

46 "La Rotonda." (https://larotonda.com.ar/)

47 Agrofy, "El mercado online del agro." (https://www.agrofy.com.ar).

48 Agtech, "MiLote." (https://www.AgTech.org.ar).

49 Quick response.

50 Artificial intelligence. According to USAID, Artificial Intelligence is the science and technology of creating intelligent systems and are often enabled by Machine Learning, to either learn or predict and apply data-derived predictions to automate decisions.

51 "Taranis." (http://www.taranis.ag/).

Challenges for digital agriculture

Despite the significant growth and great potential of digital agriculture in Argentina, several challenges are still preventing digital solutions from reaching their full potential.

Production risks caused by extreme climate events continue to increase uncertainty among Argentine farmers. Floods and droughts have an outsized impact on the agricultural sector; small- and medium-scale farmers outside the Pampas are most at risk. Additionally, small- and medium-scale farmers are often unable to afford agriculture insurance, further increasing their vulnerability to risk. These farmers generally do not have access to digital technologies or robust infrastructure, their ability to purchase hardware is very limited, and their digital literacy is low. Thus, accessible technologies with simple, integrated systems that reduce risk exposure are likely the easiest for them to adopt. For example, feature phone technology can easily correlate weather forecast data with cropping events to provide early warnings of potential production risks. The use of satellite imagery and sensors to expand agriculture insurance coverage and enable automatic payouts would help reduce transaction costs, thus making insurance services more accessible to small- and medium-scale producers. Financing the digital solutions offered by both agtech companies and startups for regional farming systems could help remove cost barriers and drive adoption.

The biggest challenge for large-scale Pampas farmers is value chain fragmentation. These highly developed production chains are currently managed with the latest innovations and digital technologies. However, these technologies frequently do not address the crucial needs of actors at various points along the value chains. Information flow among farmers is limited by siloed hubs, a lack of interconnection between end users, and disparities in technology and digital skills. For instance, many agtech companies offer data collection services that translate into descriptive analytics (charts, graphs, and plots) shown in dashboards. Nevertheless, descriptive statistics are not sufficiently detailed for large-scale farmers. Rather, their decision-making requires more precise, timely information based on robust analyses.

Intense, high-input soybean production poses a substantial environmental threat to the Argentine Pampas. This is also a region where large-scale farmers can access and afford advanced technologies. As such, advanced digital solutions such as AI[52] -based precision fertilizer and pesticide application hold great potential for making soybean systems more environmentally sustainable.

Enabling Digital Agriculture

An important first step in leveraging digital agriculture to solve real-world problems is identifying the most appropriate and promising technologies to address multiple barriers that exist in the sector. This enables investors and implementers to focus their efforts on the areas of highest impact. Once enabling factors are identified and understood, the mainstreaming of digital agriculture in Argentina can begin in earnest.[53]

In this analysis, we focus on identifying the main challenges confronting the agricultural sector for each of the end user hubs. We then identify, using participatory methods, a set of technologies and associated functions and outcomes. Table 1 shows the results of technology prioritization across hubs. The prioritized technologies address 11 challenges. Next, each technology was assessed across six dimensions: progress (that is, the current level of use or adoption), policy, potential (that is, the potential level of use or adoption and impact), efficiency (in the operation of the food system), equity, and the environment. Each of these is assessed using several indicators (Table 2). The results of the technology identification and assessment process are described below, followed by a discussion of policies, the role of the public and private sectors, and the financing options available to support the promotion of the most promising technologies.

Prioritized technologies and their impact

The technologies identified and prioritized via consultations with relevant stakeholders in Argentina can be grouped into three categories: data collection, analysis, and dissemination; blockchain and robotics for monitoring and traceability; and facilitation of automatic practices and processes during production. These technologies currently have varying levels of adoption by end users.

52 Artificial intelligence. According to USAID, Artificial Intelligence is the science and technology of creating intelligent systems and are often enabled by Machine Learning, to either learn or predict and apply data-derived predictions to automate decisions.

53 Disclaimer: These results are based on a combination of desk research and stakeholder consultations. The latter includes eight interviews with representatives of the government, academia, non-governmental organizations, service providers, farmers, and startups in digital agriculture, as well as a one-day workshop with 17 key experts in the field of digital agriculture. It is important to note that Argentina has three geographic hubs of strong digital agriculture development -- Buenos Aires, Rosario, and Córdoba -- each with a broad representation of public and private entities. The technologies discussed in this section are based on the insight of stakeholders from Buenos Aires only. As such, the challenges and potential solutions outlined here are extrapolated from these discussions.

Some enjoy high levels of adoption and have been in use for several years, while others are only beginning to be adopted. Therefore, stakeholders' perceptions about the impact of technologies varied widely. Digital solutions in general in Argentina tend to be highly integrated; as such, projects that integrate two or more of the technologies discussed here may offer even greater potential.

Data collection: This category includes digital technologies used for data capture, e.g., through satellites, drones, cameras, IoT[54], or sensing equipment. Such technologies typically generate inputs to transform raw data into actionable information. In Argentina's ag-tech ecosystem, there are at least eight startups dedicated to data collection using these technologies. Many extensive, large-scale Argentine farmers make decisions based on satellite imagery, which is far more effective and considerably less expensive than flying over their fields to pinpoint issues.

Data analysis: This category includes digital technologies used for data analysis, with a specific focus on big data and AI[55]. Big data has emerged as a multifaceted phenomenon with dramatic implications for the analysis and dissemination of data. In the agtech ecosystem in Argentina, at least 14 startups offer big data services. Combining the data capture capabilities of IoT and the machine learning capacity of AI with the power of big data enables understanding trends, which can be used to create accurate predictions and address agricultural challenges. For example, recognizing pest and disease outbreaks and conveying them through early warning systems supports more accurate and environmentally responsible pesticide spraying. Similarly, understanding market trends and consumption patterns can enable efficient supply chain development. In combination with satellites or drones, big data and AI can provide unique insights into crop management, plant disease detection, crop or tree species censes, and soil and water management.[56]

Data dissemination: Technologies in this category disseminate data or information to end users to support decision making. It includes technologies that integrate websites, mobile phone applications, and phone systems such as SMS[57] and IVR[58]. Currently, there are hundreds of free automated phone system technologies developed by small startup companies across food system hubs in Argentina. Despite their availability and the constant improvement of their functionality, their level of adoption is at best moderate. Adoption levels are related not only to digital literacy rates, but also to the types of services offered. In the production hub, for example, adoption levels tend to be higher for applications that provide a specific service to producers, such as machine rental. In addition, the potential of automated phone systems has yet to be fully leveraged. Development in this area will require policies that enable transparent data sharing, and the development of integrated information solutions across multiple food system hubs.

Potential avenues for the public sector

The role of the government is to create an enabling digital agriculture environment and provide public goods in the Argentine agricultural sector. The public sector must also prioritize long-term investments in sustainability. Digital solutions focused on advisory and information delivery are crucial for promoting environmentally sustainable practices and reducing pesticide use and soil degradation, especially for the small- and medium-scale farmers outside the Pampas region.

Public-private partnerships can facilitate the transfer of lessons learned and recommendations from digital innovators to universities and other public entities, with the ultimate goal of adapting profitable digital solutions to small- and medium-scale regional producers. The public sector could also offer incentives for large-scale producers who digitally integrate with small-scale producers, thus creating economies of scale and knowledge-sharing opportunities for farmers who may not have the financial, labor, and investment capital to be digital innovators.

Significant recent growth in agricultural risk management systems have paved the way for improved agricultural insurance services. In coordination with meteorological, sensor, and satellite information, digital technologies can enable well-developed agricultural insurance markets.[59] Public-private partnerships can also play an important role in the adoption of risk management and sustainability strategies. INTA's role in this arena could further enhance its innovation and public dissemination of knowledge related to climate change and environmental sustainability.

Finally, to address low productivity outside the Pampas region, public policies and public investments should focus on the development, adoption, and use of novel digital

54 Internet of Things.

55 Artificial intelligence. According to USAID, Artificial Intelligence is the science and technology of creating intelligent systems and are often enabled by Machine Learning, to either learn or predict and apply data-derived predictions to automate decisions.

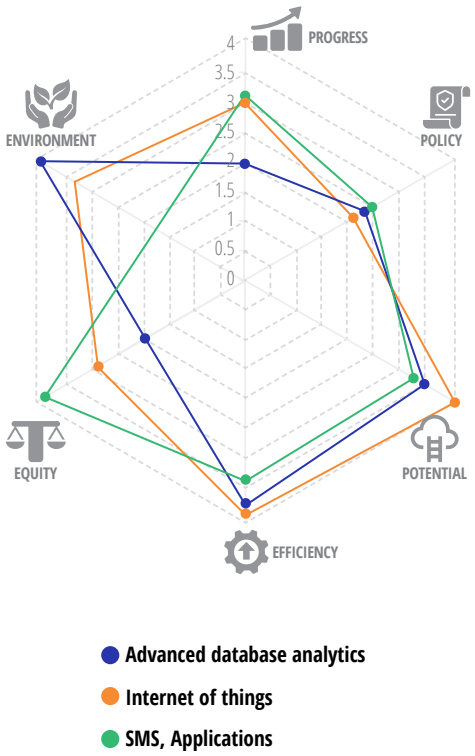
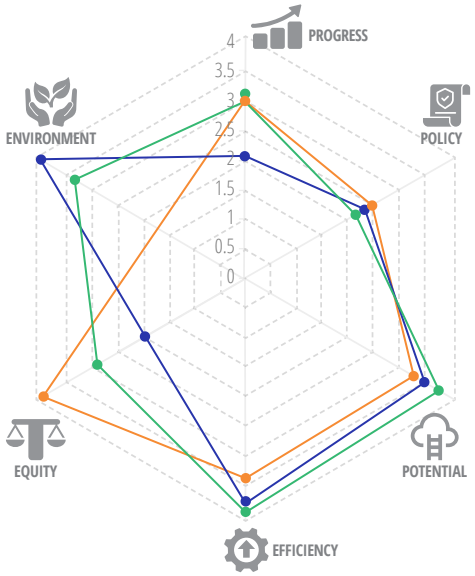
56 Gray et al., "Digital Farmer Profiles: Reimagining Smallholder Agriculture."

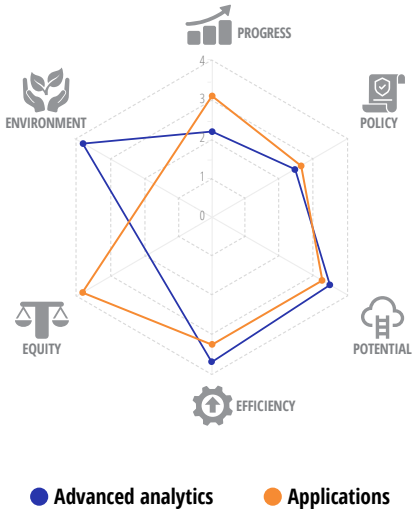
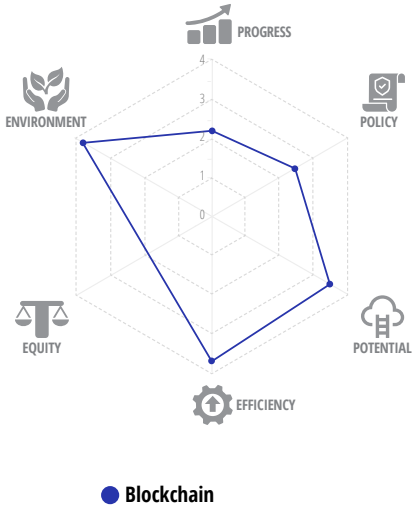
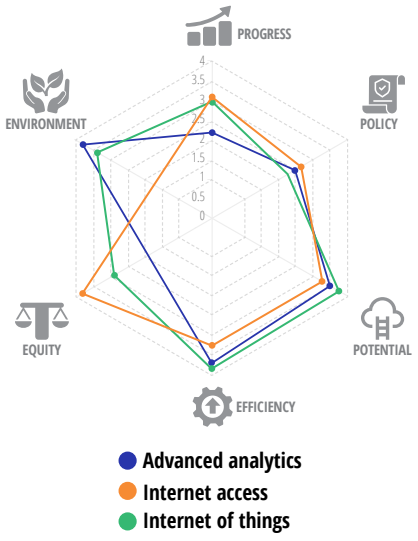
57 Short Messaging Service.

58 Interactive Voice Response.

59 OECD Food and Agricultural Reviews, "Agricultural Policies in Argentina."

Table 1: Prioritized technologies

	Challenge	Technology	Outcome	Analysis
INPUT HUB	Lack of information on services and inputs required by farmers	**Advanced analytics on agricultural inputs/services'**	Improved farm management decision-making processes	
	Lack of updated information on farming systems and landscapes	**Internet of Things and remote sensing for monitoring**	Improved decision-making and competition in input markets	
		SMS, applications for monitoring		
PRODUCER HUB	Lack of decision support systems that provide actionable and gender-differentiated information	**Advanced analytics for actionable advisory systems**	Improved on-farm decision support tools	
	Lack of producer communication for knowledge exchange	**Online platforms for producer information sharing**	Producers have access to knowledge sharing	
	Lack of efficient precision farming options and low mechanization	**Robotics for higher mechanization**	Reduced labour inputs and more efficient use of resources through mechanized precision agriculture	

	Challenge	Technology	Outcome	Analysis
DISTRIBUTION HUB	Lack of monitoring and integration of value chains	**Advanced analytics for integration of value chains**	Improved time and resource efficiency, increased profitability through optimized supply and demand according to consumer markets	
	Lack of information on supply, demand, supplier networks, transformation, and distribution logistics	**Applications for tracking and providing real-time information**		
CONSUMER HUB	Lack of product traceability	**Blockchain for traceability**	Consumers use digital means to access information on their food purchases	
CROSS-CUTTING HUB	Lack of access to the full range of services digitally available	**Advanced analytics for solutions integration**	Stakeholders across the value chain have the capacity to both use and offer digital solutions	
	Lack of information transparency and accuracy	**Broadband (3G, 4G, 5G), Bluetooth, wireless, infrared to ensure everyone has access to digital tools**	Better flow of information across the value chain	
	Poor enabling policy environment	**Internet of things to optimize decision making**	Improved enabling environment for digital agriculture	

technologies to support agricultural infrastructure, R&D,[60] and productive strategies for each value chain.

Potential avenues for the private sector

Private sector incubators, accelerators, and investment funds are effective in fostering the development of digital agriculture solutions. It is, therefore, necessary to identify sustainable business models that allow startups and small- and medium-scale enterprises in the technology market to thrive. Our findings suggest that a suitable business model in Argentina requires users to pay for services. Such a model makes businesses economically viable and contributes to healthy competition between companies and startups in terms of quality and price. This drives down prices, ultimately opening up services and technologies to those with more limited economic resources. There are also many private-sector opportunities to address the environmental damage of unsustainable agricultural intensification. For instance, analytic companies can provide insights on how to implement environmentally sustainable practices, such as precise pesticide and fertilizer application rates and soil characterization, at the regional level.

Domestic investment attracts the attention of international investors. With support from the government of Argentina, agtech investors are starting to take note of the potential for digital agriculture in the country. Support from both public and private initiatives aimed at promoting innovation contributes to this attention. One example is the Trust Fund for the Development of Entrepreneur Capital (FONDCE), which invests up to US$100,000 in innovations in the technological, social, and scientific sectors.

Outlook

Argentina has laid a strong foundation for digital agricultural solutions, and its digital agriculture ecosystem is flourishing. Connectivity and subscription rates are high, and several digital solutions in agriculture have met with significant success. This suggests great potential to improve efficiency, equity, and environmental sustainability in Argentine agriculture.

Our research suggests that stakeholders who focus their efforts on the following arenas are most likely to bring high-impact solutions to Argentina's agricultural sector: (1) integrating agricultural solutions along the value chain; (2) implementing environmentally sustainable practices through applied data both in and outside of the Pampas region; (3) providing improved access to services—including advisory services, credit and financial services, insurance, inputs, and market access—for small- and medium-scale farmers outside the Pampas region. Supportive public-sector investment, private-sector engagement in innovation and monetization, and international donor support will all be crucial to ensuring the success of such solutions.

60 Research and Development.

References

Agrofy. “El mercado online del agro,” 2019. https://www.agrofy.com.ar/.

Agtech. “MiLote.” Aapresid, 2018. https://www.agtech.org.ar/.

CIAT. Julián Baldunciel, farmer, entrepreneur, agtech investor, and founder of Acronex., April 2020.

Club AgTech. “Balance del mercado Agtech 2018,” January 16, 2019. http://www.clubagtech.com/balance-del-mercado-agtech-2018-3/.

Food and Agriculture Organization of the United Nations. “FAOSTAT,” 2019. http://www.fao.org/faostat/en/#data/TP.

INTA argentina. INTA Agencia Virtual, Una Nueva Forma de Acercarnos, 2019. https://www.youtube.com/watch?v=Mc6ywAdRrww.

International Telecommunication Union. “Global and Regional ICT Estimates.” Statistics, 2018. https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx.

“Global ICT Development Index,” 2017. https://www.itu.int/net4/ITU-D/idi/2017/index.html.

“La Rotonda,” 2016. https://larotonda.com.ar/.

nPerf. “2G / 3G / 4G Coverage in Argentina,” 2019. https://www.nperf.com/en/map/AR/-/152394.Personal-Mobile/signal/?ll=-35.14985730495559&lg=-58.952636718750 01&zoom=5.

OECD Food and Agricultural Reviews. “Agricultural Policies in Argentina.” Paris: OECD iLibrary, 2019. https://read.oecd-ilibrary.org/agriculture-and-food/agricultural-policies-in-argentina_9789264311695-en.

tarani.ag. “Taranis,” 2019. http://www.taranis.ag/.

The World Bank. “Poverty Rates | Argentina.” Data, 2017.

Trigo, Eduardo, Maria Carmen Fernandez Diez, Juan Carlos Mendez, and Francisco Demichelis. “La Revolución Agrotech En Argentina: Financiamiento, Oportunidades y Desafíos,” June 2018. http://dx.doi.org/10.18235/0001154.

UNDESA. “World Population Prospects.” Health. New York, 2017.

United Nations. “Argentina.” UN E-Government Knowledgebase, 2018. https://publicadministration.un.org/egovkb/en-us/Data/Country-Information/id/7-Argentina.

World Bank. “Socio-Economic Sustainability.” World Development Indicators Database, 2018. https://data.worldbank.org/.

“Total Population: Argentina,” 2018.

List of Authors

Luis Armando Munoz,[1] Maria Camila Gómez,[1] Daniel Jiménez,[1] Eva Hasiner,[2] Kateryna Schroeder,[2] David Treguer,[2] Armine Juergenliemk,[2] Alexandra Horst,[2] Andy Jarvis[1] and Wietske Kropff[1]

This document has benefited from comments received from: Carlo Bravi[3].

Editor: Megan Mayzelle
Design: Daniel Gutiérrez[1]

1 The Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT)

2 The World Bank

3 FAO, Food and Agriculture Organization of the United Nations

---

The concept of this series of digital agriculture country profiles are based on the concept of the climate smart agriculture country profiles developed by CCAFS.

The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), led by the International Center for Tropical Agriculture (CIAT), brings together some of the world's best researchers in agricultural science, development research, climate science and Earth System science, to identify and address the most important interactions, synergies and tradeoffs between climate change, agriculture and food security. www.ccafs.cgiar.org.