TFCCT Educator Award

Reviewing the Agri-Tech Innovation Landscapes of the United States of America and Brazil to Identify Areas for Collaboration

Dr Jenna Ross OBE

Crop Health and Protection

February 2024

Contents

1. Introduction

Dr Jenna Ross OBE (Fig. 1) is a farmer's daughter from Aberdeenshire with a passion for driving innovation in agriculture.

Jenna holds a PhD in Environmental Science, as well as an MBA with Distinction, Diploma in Management and Leadership, First Class Honours Degree, Executive Education in Global Business, Windsor Leadership Trust training and has over 15-years of international development and academic experience.

Figure 1: Dr Jenna Ross OBE - author of this report (Source: Author)

She has completed a Nuffield Farming Scholarship where she spent 26-weeks travelling the world in 2018 studying global opportunities in agriculture with a specific focus on slug control. She has received awards from LANTRA, CARAS, Scottish Land and Estates Helping it Happen, Aberdeen Business School, Chartered Management Institute (CMI), Royal Northern Agricultural Society, Nuffield Farming Scholarship Trust (HSBC Salver and Greener Future Award) and was selected as one of the top five MBA graduates in the world by Association of MBA's.

She is highly published, and is an active STEM ambassador, Trustee of The Farmers Club Charitable Trust, a LANTRA Industry Champion, Chartered Companion of CMI (CMgr CCMI), board member of CMI Scotland, immediate past Chair for Nuffield Scotland, Trustee of Nuffield Farming Scholarships Trust, Director of Inclusive Farm Scotland at MacRobert, Associate of CARAS (ARAgS), founding board member of the Africa Scotland Business Network, Honorary Fellow of the University of Aberdeen and past Director of the Oxford Farming Conference.

Jenna received an OBE in Her late Majesty The Queen's final honours list in June 2022 as part of the Jubilee celebrations in recognition for her work in agriculture and science. She was also named as a Coronation Champion, an award launched by the Royal Voluntary Service, alongside Her Majesty The Queen Consort, to celebrate the work of extraordinary volunteers across the UK in His Majesty The King's Coronation year.

Jenna currently works for UK Government funded Agri-Tech centre, Crop Health and Protection (CHAP) (soon to be known as the Agri-Tech Centres), leading its international development with high impact projects spanning the globe. Jenna brings together leading scientists, farmers, advisors, innovators, Government and businesses to help understand industry challenges and priorities, and work with these stakeholders to drive game changing research and innovation that transforms crop systems.

CHAP has an expanding network that includes the following academic partners:

- Rothamsted Research
- Newcastle University
- Cranfield University
- James Hutton Institute
- CABI
- Fera
- NIAB
- Stockbridge Technology Centre (STC)
- University of Warwick

CHAP's extensive network will be utilised to disseminate the results of this report.

2. Project Background

Globally, agriculture and its associated axillary industries, face the challenge of increasing the quantity of nutritious and healthy food to meet the demands of a growing world population, whilst also delivering significant environmental gains through improved soil health, addressing biodiversity loss, water scarcity, decreasing carbon emissions and delivering on the Sustainable Development Goals (SDGs), ensuring a thriving, equitable and healthy world (Benton et al., 2021; UN, 2023). Furthermore, the industry faces challenges and expectations set by regulators, consumers, food processors and retailers, as well as the impact of COVID-19, geopolitical instability, energy costs, fertiliser prices, inflation and subsequent food unaffordability, all of which are threatening global food security (UN, 2023).

Core to the aforementioned challenge is the need to increase productivity, profitability and efficiency to deliver a resilient and sustainable food system, as part of the wider climate change solution. A key component to addressing this conundrum is the advancement of science and technology, and its fundamental role in the development of game changing Agri-Tech solutions.

The term ‘Agri-Tech’ defines a wide range of technological, science-based and/or practice innovations for pre and post farm gate, including, but not limited to, agriculture, horticulture, aquaculture, forestry, storage, food processing and animal health (AgFunder, 2023; AgFunderNews 2023; Agri-Tech Centres, 2024).

The global Agri-Tech market is rapidly expanding and is one of the top ten fastest growing sectors for venture capital funding. Agri-Tech is expected to exceed USD 75,872.5 million by 2032, with a CAGR of 13.1%, with the Americas predicted to grow the fastest during the forecasted period (Spherical Insights, 2024).

Of the Americas, deal activity/investment showed (AgFunder, 2023):

- Total raised by companies in the United States of America (USA) accounted for a significant proportion of deals with those based in California raising USD 5.3 billion in 2022.

- Brazil is the largest Latin American market for Agri-Tech with nearly 50% of market share with technologies spanning the supply chain.

As such, this report will focus on the innovation landscapes of both the USA and Brazil and review areas for collaboration for UK Agri-Tech.

3. Aim and Objectives

3.1 Aim

The aim of this project was to review the Agri-Tech innovation landscapes of the USA and Brazil to identify areas of collaboration.

3.2 Objectives

The objectives of the project were to travel to the USA and Brazil to:

1. Understand the challenges facing agriculture in the respective countries.
2. Understand the development and adoption of innovation.
3. Investigate the opportunity for collaboration with the UK Agri-Tech ecosystem.

4. Research Approach and Methodology

This study involved visiting with farmers, research institutes, innovation networks, advisors, start-ups, accelerators and incubators, and attending three conferences. Each visit involved generating both qualitative and quantitative data. Two countries were visited: USA and Brazil. These countries were chosen due to their game changing innovative nature, conference locations and their collaborative opportunities.

Details of the chronological travel plan can be found in Table 1.

Table 1: Travel Plan (Source: Author)

Date	Country	Organisation	Contact
February 2023	USA (California)	British Consulate, San Francisco	Facilitated by Hannah Davelman (Senior Science & Innovation Officer), and joined by Simon Pearson (Founding Director, LIAT, University of Lincoln), Chris Baker (Science Director, Intelligent Data Ecosystems, Rothamsted Research) and Leon Terry (Pro-Vice Chancellor for Research and Innovation, Cranfield University).
February 2023	USA (California)	University of California Davis (UC Davis)	Gail Taylor (Professor of Environmental Plant Science) Steve Brown (Associate Director, Artificial Intelligence Institute for Next Generation Food Systems) Jim Pantaleo Business Development Coordinator, Artificial Intelligence Institute for Next Generation Food Systems) Christine Diepenbrock (Assistance Professor) Mason Earles (Assistance Professor) Nitin Nitin (Assistance Professor)

			Joined by Simon Pearson (Founding Director, LIAT, University of Lincoln), Chris Baker (Science Director, Intelligent Data Ecosystems, Rothamsted Research) and Leon Terry (Pro-Vice Chancellor for Research and Innovation, Cranfield University).
February 2023	USA (California)	University of California Merced (UC Merced)	Leigh Bernacchi, Center for Information Technology Research in the Interest of Society (CITRIS) and the Banatao Institute, UC Merced Joshua Viers, Associate Dean for Research, School of Engineering, and Lead, USDA-NIFA Institute for Agricultural AI for Transforming Workforce and Decision Support Brandon Stark (aviation, remote sensing) Colleen Naughton (tomatoes LCA—sustainability) Danny Royer (smart farm) J. Andrés Morandé (sustainable agriculture and cropping systems) Josh Viers (remote sensing, AgAID) Josué Medellín-Azuara (water information and labour economics) Lisa Yeo (digital agriculture, information infrastructure)

			Reza Ehsani (agricultural engineering) Ricardo Pinto de Castro (agricultural engineering) Safeeq Khan (water and climate change) Teamrat Ghezzehei (soil) Tom Harmon (digital agriculture) Wan Du (digital twin) Xiaoyi Lu (big data, hpc, deep learning) YangQuan Chen (controlled environment systems) Joined by Simon Pearson (Founding Director, LIAT, University of Lincoln), Chris Baker (Science Director, Intelligent Data Ecosystems, Rothamsted Research) and Leon Terry (Pro-Vice Chancellor for Research and Innovation, Cranfield University).
February 2023	USA (California)	World Ag Expo	Tammy Sandhu MBE (British Consul General San Francisco) Congressman Jim Costa Under-Secretary Christine Birdsong Joined by Simon Pearson (Founding Director, LIAT, University of Lincoln), Chris Baker (Science Director, Intelligent Data Ecosystems, Rothamsted Research) and Leon Terry (Pro-Vice Chancellor for Research and Innovation, Cranfield University).

February 2023	USA (Illinois)	British Consulate Chicago	Facilitated by Hannah Davelman (Senior Science & Innovation Officer) and Tim Bakke (Senior Trade Policy Advisor, British Consulate Chicago) and joined by Simon Pearson (Founding Director, LIAT, University of Lincoln), Chris Baker (Science Director, Intelligent Data Ecosystems, Rothamsted Research) and Leon Terry (Pro-Vice Chancellor for Research and Innovation, Cranfield University).
February 2023	USA (Illinois)	University of Illinois Urbana-Champaign	Susan Martinis (Vice Chancellor of Research and Innovation) Matt Hudson (Professor, Crop Sciences, Co-director, Center for Digital Agriculture) Vikram Adve (Donald B. Gillies Professor of Computer Science, Co-director, Center for Digital Agriculture) Jessica Wedow (Executive Director of AIFARMS) Madhu Khanna (Director of iSEE, ACES Distinguished Professor in Environmental Economics) John Reid (Research Professor in Computer Science and Agricultural and Biological Engineering) Melanie Rodriguez (Program Manager, Center for Digital Agriculture) Joined by Simon Pearson (Founding Director, LIAT, University of Lincoln), Chris Baker (Science Director, Intelligent Data Ecosystems, Rothamsted

			Research) and Leon Terry (Pro-Vice Chancellor for Research and Innovation, Cranfield University).
March 2023	USA (California)	United States Department of Agriculture (USDA) - Agricultural Research Service (ARS)	Bill Orts (Centres Director) Joined by Hannah Davelman (Senior Science & Innovation Officer)
March 2023	USA (California)	World Agri-Tech Innovation Summit	Rethink Events
March 2023	São Paulo, Brazil	World Agri-Tech South America Summit	Rethink Events
March 2023	São Paulo, Brazil	Embrapa	Janaína Tanure (Embrapa) Mark Jarman (AgriTIERRA)
March 2023	São Paulo, Brazil	Brazilian British Centre, São Paulo	Laura Flaquer Moreira, (Science and Innovation Network) Gabriela Meucci (Department for Business and Trade)

Each visit involved generating both qualitative and quantitative data on the following topics:

1. Challenges facing agriculture in the respective country.
2. Development and adoption of innovation.
3. Opportunities for collaboration with the UK Agri-Tech ecosystem.

An overview of each location visited is detailed in Section 5, with a discussion on the above topics in Section 6.

5. Study Locations

5.1 United States of America

The United States of America (USA) is the world's second largest agricultural trader, after the European Union, and is ranked number one in the Agri-Tech startup ecosystem (StartupBlink, 2023). Agriculture, food and related industries contributed 5.4% to USA gross domestic product (GDP) in 2021, equating to approx. USD 1.264 trillion, with direct farm outputs contributing USD 164.7 billion (0.7% of USA GDP). Sectors relating to agriculture are inclusive of food/beverage manufacturing, food services, textiles/leather products, forestry and fishing. Overall, agriculture accounts for 10.4% of employment in the USA (USDA, 2023a), with 2 million farms, covering 893 million acres with an average farm size of 446 acres (USDA, 2023b).

5.1.1 California

California, the USA's most productive agricultural state, has over 76,400 farms, equates to USD 54 billion and generates over 400 agricultural commodities, including, but not limited to, fruits, nuts, forage, fibre, grains, legumes, vegetables, fisheries and livestock. California produces over a third of the country's vegetables, and nearly two-thirds of its fruits and nuts. Furthermore, it is the primary producer of almonds, clingstone peaches, grapes, pistachios and walnuts, making up over 28% of the state's direct agricultural value. The top ten valued commodities produced in California (FY= 2022) are detailed in Table 2 (CDFA, 2023; USDA, 2023c).

Table 2: Top ten valued commodities produced in California (FY= 2022)(CDFA, 2023)

Top 10 valued commodities produced in California (FY= 2022)	
Commodity Type	**Value (USD)**
Dairy Products (Milk)	10.40 billion
Grapes	5.54 billion
Cattle and Calves	3.63 billion
Almonds	3.52 billion

Lettuce	3.15 billion
Strawberries	2.68 billion
Pistachios	1.86 billion
Broilers	1.59 billion
Tomatoes	1.46 billion
Carrots	1.11 billion

California is a key exporter, accounting for USD 22.5 billion in 2021, an increase of 7% from the previous year, with key exports including almonds, dairy products, pistachios, wine and walnuts (CDFA, 2023).

California is leading the way for USA cutting-edge Agri-Tech developments, raising USD 5.3 billion in 2022. This is supported by a strong R&D landscape, with California home to University of California Davis, one of the world's top ten agricultural science universities (CA GOV, 2023). It is also home to eleven Tier 1 research universities, with research spanning from breeding through to biofuels (CA GOV, 2023).

Therefore, with its world-class R&D facilities, rapidly growing startup scene, and its globally dominating agriculture industry, California was essential to visit in order to gain access to the forefront of technological innovations.

Locations visited included:

- University of California Davis
- University of California Merced
- World Ag Expo
- World Agri-Tech Innovation Summit
- United States Department of Agriculture (USDA) - Agricultural Research Service (ARS)

5.1.1.1 University of California Davis

University of California Davis, known as UC Davis, was founded in 1908 to serve the state of California. It was initially the University Farm to support research at University of California Berkely (known as UC Berkely), so agriculture is at its core. It is now

ranked as one of the world's top universities with 38,347 students, 107 academic majors, 6 professional schools, 101 graduate degrees and secured over USD 1 billion in research grant funding in FY21/22 (UC Davis, 2023).

A visit to UC Davis was conducted in February 2023 and hosted by Gail Taylor, Steve Brown and Jim Pantaleo, and kindly facilitated by Hannah Davelman, Senior Science & Innovation Officer, British Consulate, San Francisco, and joined by Simon Pearson (Founding Director, LIAT, University of Lincoln), Chris Baker (Science Director, Intelligent Data Ecosystems, Rothamsted Research) and Leon Terry (Pro-Vice Chancellor for Research and Innovation, Cranfield University)(Fig. 2).

The aim was to receive an overview and understanding of the workings of the Artificial Intelligence Institute for Next Generation Food Systems, more commonly known as AIFS, and discuss areas for UK collaboration.

Figure 2: Visit to Artificial Intelligence Institute for Next Generation Food Systems at UC Davis including (from left) Steve Brown, Hannah Davelman, Jim Pantaleo, Simon Pearson, Leon Terry, Chris Baker, Jenna Ross and Gail Taylor

Artificial Intelligence Institute for Next Generation Food Systems

AIFS was launched on the 1st October 2020 to understand the world's greatest challenges associated with crop and food production, and develop game changing solutions for more sustainable, nutritious, efficient and safe food systems, whilst mitigating the effects of climate change. The institute, which is funded by the USDA National Institute of Food and Agriculture (Grant no. 2020-67021-32855/project accession no. 1024262), is part of a larger initiative led by the United States National Science Foundation, and has taken an innovative, inclusive and collaborative approach to deliver open-source artificial intelligence (AI) solutions for the industry (AIFS, 2023). It places AI at the heart of its offering and considers:

- Multidisciplinary approach to address complex food system challenges.
- Gathers diverse data sets and develops models.
- Takes a human-centric approach.
- Focuses on industry engagement and workforce development.

The institute brings together more than 40 researchers across six institutes (AIFS, 2023):

- UC Davis
- UC Berkeley
- Cornell University
- University of Illinois, Urbana-Champaign
- UC Agriculture and Natural Resources
- US Department of Agriculture's Agricultural Research Service

Across the aforementioned collaborators, there are six focal areas (AIFS, 2023):

- Molecular breeding
- Agricultural production
- Food processing and distribution
- Nutrition
- Core AI technology
- Socioeconomic impact of AI

Key challenges addressed by AIFS (2023) include:

- Integration of both digital and biological technologies to deliver solutions that address our complex and diverse food systems.
- Development of publicly available models and data sets for AI.
- Deliver safe, efficient and accurate food system tasks requiring human involvement and decision-making.

As part of this visit, as overview was provided on various AI driven projects detailed in Appendix 1.

5.1.1.2 University of California Merced

The University of California Merced, known as UC Merced, is a public land-grant research university based in Merced. It is one of ten campuses as part of the University of California (UC) system, and was established in 2005, making it the University of California system's newest campus and the nation's first research institution of the 21st century (UC Merced, 2023a).

A visit to UC Merced was conducted in February 2023 and hosted by Leigh Bernacchi and Joshua Viers, and was kindly facilitated by Hannah Davelman, Senior Science & Innovation Officer, British Consulate, San Francisco, and Tammy Sandhu MBE, Consul General, British Consulate San Francisco (Fig. 3).

The aim of the visit was to gain an overview of UC Merced's involvement with:

- The Center for Information Technology Research in the Interest of Society (CITRIS)
- USDA-NIFA Institute for Agricultural AI for Transforming Workforce and Decision Support
- University of California Merced Experimental Smart Farm

Figure 3: Visit to UC Merced including (from left) Jenna Ross, Simon Pearson, Chris Baker. Hannah Davelman, Tammy Sandhu MBE, Leon Terry

The Center for Information Technology Research in the Interest of Society (CITRIS)

The Center for Information Technology Research in the Interest of Society and the Banatao Institute (CITRIS) is a collaboration between University of California campuses at Berkeley, Davis, Merced and Santa Cruz, and facilitates interdisciplinary research delivering new innovative solutions and disrupting industries. It works with a range of stakeholders from start-ups through to policymakers and researchers. CITRIS (2023) focuses in the following areas:

- CITRIS Aviation – supports the development of cutting-edge technologies, applications and policies associated with vehicles for flight with the aim of delivering social and economic impact.

- CITRIS Climate – Application of technologies to tackle climate change, with a specific focus on climate justice and equity among underrepresented and underserved communities.
- CITRIS Health - Application of innovative technologies, such as telehealth, sensors, analytics and mobile devices, to deliver cost-effective health care.
- CITRIS People and Robots – Development of socially responsible multidisciplinary robotics with a human-centric focus.
- CITRIS Policy Lab – Addressing formal and informal regulation for technology development through research, education and thought leadership.
- EDGE in Tech Initiative - Addressing challenges faced by women and other under-represented identities in engineering and computer science.

USDA-NIFA Institute for Agricultural AI for Transforming Workforce and Decision Support (AgAID)

USDA-NIFA Institute for Agricultural AI for Transforming Workforce and Decision Support (AgAID, 2023) brings together AI, agriculture and human systems to deliver a transdisciplinary ecosystem for technology innovation and knowledge transfer, in order to drive sustainable agricultural systems to enhance productivity thus meeting future food demands. This is a collaboration between:

- UC Merced
- Oregon State University
- University of Virginia
- Wenatchee Valley College
- Kansas State University
- Washington State University
- Heritage University
- Innov8.ag
- IBM Research

The institute focuses on three principles:

- Adopt - First rule in AI design.
- Adapt – To complex and changing environments and scalability.

- Amplify - Human skills alongside machine efficiency to deliver a human-AI partnership.

Areas of focus include:

- Farm intelligence
- Water intelligence
- Labour intelligence
- Modelling systems
- Multi-scale decision support
- Interactive human-AI workflows

University of California Merced Experimental Smart Farm

UC Merced's Experimental Smart Farm (ESF) was launched in 2021 through funding from the State of California (UD Merced, 2023b). It is spread across 45 acres and supports research on sustainable land management, regenerative agriculture, precision agriculture, automation/robotics, machine learning/AI and development of the future of farm work. The farm is also used to support creative arts, community, outreach and learning opportunities.

5.1.1.3 World Ag Expo

The World Ag Expo (2024) is one of the largest annual outdoor agricultural Expos with over 100,000 attendees each year. It started in 1968 and is now held at the International Agri-Center in Tulare across 2.6 million square feet.

Attendance at the World Ag Expo took place in February 2023 and was facilitated by FCDO SIN Officer Hannah Davelman, with the opportunity to visit stands and meet with US Agri-Tech businesses, farmers, researchers and Government departments. In addition, the UK delegation attendees were invited to participate in the British Consulate side event. Topics of discussion included UK/US opportunities for collaboration, agricultural landscape, use of AI, Agri-Tech investment, technologies to mitigate for climate change and improved adoption of Agri-Tech. Speakers included British Consul General San Francisco Tammy Sandhu MBE, Congressman Jim Costa,

Under-Secretary Christine Birdsong, Colin Hassard, Jenna Ross, Simon Pearson, Chris Baker and Leon Terry.

5.1.1.4 World Agri-Tech Innovation Summit

The World Agri-Tech Innovation Summit is held in San Francisco each year and brings together founders, corporates, investors and experts from across Agri-Tech to discuss challenges and opportunities within the industry (World Agri-Tech Innovation Summit, 2023). The March 2023 conference marked the summits eleventh anniversary, bringing a global audience of over 2500 stakeholders together. The 2023 theme was Future-Proofing Resilience in Ag: with a focus on the Climate-Water-Energy-Food Nexus.

Key topics raised included:

- Next generation crop protection
- Biologicals
- Crop nutrition
- AI
- Robotics and automation
- Labour shortages
- Soil health
- Precision ag
- Remote sensing
- Data
- Satellite data
- Sensors
- Agri-financing

The conference had a strong focus on entrepreneurship, with a dedicated start-up arena allowing founders and young companies to showcase their solutions. There were also various interactive break-out sessions, as well as drop-in clinics and roundtable discussions to facilitate easier and faster networking, exchange of ideas and identification of potential future collaborators/partners. Organisations that participated in the World Agri-Tech Innovation Summit 2023 are summarised in Fig. 4 with photos from attendance in Fig. 5.

Figure 4: Participants of the World Agri-Tech Innovation Summit 2023 (Source: World Agri-Tech Innovation Summit, 2023)

Figure 5: Attendance at the Agri-Tech Innovation Summit 2023 (Source: Author)

5.1.1.5 United States Department of Agriculture (USDA) - Agricultural Research Service (ARS)

The Agricultural Research Service (ARS) is the scientific research agency for the United States Department of Agriculture (USDA), and comprises over 2,000 researchers, 660 research projects, over 90 research locations and has a budget of USD 1.7 billion per fiscal year.

A visit to the ARS's Western Regional Research Center, located in Albany, CA, was hosted by the Center's Director, Bill Orts, and was kindly facilitated by Hannah Davelman, Senior Science & Innovation Officer, British Consulate, San Francisco.

The aim of the visit was to gain an overview of the ARS's Western Regional Research Centre research (Fig. 6).

ARS's Western Regional Research Center

The Western Regional Research Center, established following the Agricultural Adjustment Act of 1938, was created alongside the Eastern Regional Research Centre (Wyndmoor, Pennsylvania), Southern Regional Research Centre (New Orleans, Louisiana), and the Northern Regional Research Centre (now National Centre for Agricultural Utilization Research) (Peoria, Illinois) (USDA, 2023d).

It delivers cutting-edge, scientific tools and innovative solutions to farmers, producers and industry in the USA.

Research falls within the following main themes:

- Bioproducts research.
- Crop improvements and genetics.
- Foodborne toxin detection and prevention.
- Healthy processed foods.
- Invasive species and pollinator health.
- Produce safety and microbiology.

The Western Regional Research Center has also been recognised as a National Historic Chemical Landmark in 2002 for its work in frozen food production, and in 2013 for research in flavour methods and standards.

Figure 6: Visit to ARS's Western Regional Research Center (Source: Author)

5.1.2 Illinois

Illinois generates USD 51.1 billion agricultural commodities annually and ranks fifth of all states on export of agricultural products accounting for USD 10.6 billion. The average size of an Illinois farm is 375 acres, with a total of 72,000 farms covering 27 million acres, primerily producing grain, as well as beef and dairy, alfalfa, canola, nursery products, emus and fish (Illinois Department of Agriculture, 2023).

5.1.2.1 University of Illinois Urbana-Champaign

The University of Illinois Urbana-Champaign**,** established in 1867, is one of the original 37 public land-grant research universities created by President Lincon after the Morrill Act 1862. The University is set across the twin cities of Champaign and Urbana, approx. 140 miles south of Chicago (University of Illinois, 2023a).

A visit to the University of Illinois Urbana-Champaign was conducted in February 2023 and was hosted by Matt Hudson and Vikram Adve, and was kindly facilitated by

Hannah Davelman, Senior Science & Innovation Officer, British Consulate, San Francisco, and Tim Bakke, Senior Trade Policy Advisor, British Consulate Chicago. Also in attendance was Simon Pearson (Founding Director, LIAT, University of Lincoln), Chris Baker (Science Director, Intelligent Data Ecosystems, Rothamsted Research) and Leon Terry (Pro-Vice Chancellor for Research and Innovation, Cranfield University).

The aim of the visit was to gain an overview of The Center for Digital Agriculture (CDA), University of Illinois Urbana-Champaign**.**

Center for Digital Agriculture (CDA)

The Center for Digital Agriculture (CDA) brings together farmers, researchers and industry to drive innovative solutions across four main themes:

- Automation.
- Data.
- Animals and Crops.
- People.

The aim of the center is to catalyse interdisciplinary research across the National Center for Supercomputer Applications (NCSA), Institute for Genomic Biology (IGB), College of Agricultural, Consumer and Environmental Sciences (ACES) and the Grainger College of Engineering, to address fundamental challenges across computing, engineering, agriculture and food.

Two initial projects have been established at the Center:

Digital Farm Infrastructure

This is a flexible and customizable IoT toolkit that includes open hardware and software for instrumented, networked, semi-automated and cloud-backed capabilities in order to perform on-farm trials of sensor-driven solutions, novel equipment, environmental monitoring and data-driven R&D for both plants and livestock.

Agriculture Data Collaboratory

This brings together data science, machine learning, information retrieval, distributed systems and high-end computing for a wide range of agriculture-based applications.

The facility is housed at the National Center for Supercomputer Applications (NCSA) with cutting-edge computing networking and visualization equipment, supporting large-scale data storage, data sciences, and data-driven decision making (University of Illinois, 2023b).

5.2 Brazil

The agriculture, livestock and fisheries sector in Brazil contributed 5.1% of total GDP, 24.6% of total exports and 3.7% of total employment in 2018, and is one of the main drivers of the economy. Recent political and economic instability, alongside drought and haulage strikes, have had a knock-on impact on the industry. However, Brazil remains one of the largest producers of coffee, soybean, maize, orange juice, pulp, sugarcane and cotton.

Brazil's agricultural industry has grown significantly since the mid-1970's, where the country was in an extremely precarious situation regarding food insecurity and was a net importer of basic foods and produce. Brazil has gone from producing 38 million tons of grain in 1975 to 262 million tons in 2021 (Radar AgTech, 2021). Part of this growth is due to heavy investment into agricultural research with the aim of increasing productivity and production. This led to the establishment of Embrapa (2023), the Brazilian Agricultural Research Corporation, which in partnership with state owned universities and research institutes, established clear priorities with regards to adoption of technologies, genetic selection and developing new practices. This is particularly evident in the Brazilian Midwest, where acid soils with heavy aluminium have gone from being seen as infertile, to being used to produce soybean due to the increased understanding of the soil characteristics and adaption of practices.

Brazil is now in the position that it is self-sufficient in the production of fresh produce and a major global player in the wider food supply chain. However, like the rest of the world, it faces significant challenges. As such, Embrapa set up 'Agropensa', assessing the megatrends predicted to impact the Brazilian agricultural industry. Details of this was published under 'Visão 2030: o future da agricultura brasileira'.

Seven megatrends were identified:

1. Socioeconomic and spatial changes in agriculture.
2. Intensification and sustainability of agricultural production systems.
3. Climate change.
4. Risks in agriculture.
5. Value adding in agricultural production chains.
6. Consumer protagonism.
7. Technological and knowledge convergence in agriculture.

The report highlighted the opportunities for information and communication technologies (ICT) to reduce physical, political and cultural barriers globally, and increase access to raw materials, goods and services.

A visit to Brazil was conducted in June 2023 and included the following meetings:

- World Agri-Tech South America Summit.
- Embrapa.
- UK Government in São Paulo.

5.2.1 World Agri-Tech South America Summit

The World Agri-Tech South America Summit, a sister event to the World Agri-Tech Innovation Summit, was held in São Paulo, and highlighted the specific challenges and innovations within the South America Agri-Tech system. It brought together growers, farmers, founders, start-ups, corporates, investors, government and experts from across the region (World Agri-Tech South America Summit, 2023).

Topics covered included:

- **Climate-Smart Production**: Building environmental and economic resilience in farming.
- **Biologicals:** Harnessing nature to create more resilient and profitable products.
- **The Digitized Farm:** Increasing the scale and adoption of smart farming solutions.
- **From Farm to Cloud:** Capitalizing on increased rural connectivity.

- **Distribution:** Accessing new channels to drive technologies and services to farmers.
- **Smart Commodities**: Enabling supply chain traceability from farm to fork.
- **Agri-Fintech:** De-risking finance for farmers and the value-chain via digital platforms.
- **Future Crops:** Overcoming barriers to gene editing and new breeding technologies.
- **Farmer Spotlight:** Accelerating innovation through field trials and collaboration.
- **ESG Finance**: Unlocking new sources of investment for the growing Agri-Tech ecosystem.

The event also supported interactive break-out sessions, networking and roundtable discussions. Organisations that participated in the World Agri-Tech South America Summit 2023 are summarised in Fig. 7 with photos from attendance in Fig. 8.

Figure 7: Participants of the World Agri-Tech South America Summit 2023 (Source: World Agri-Tech South America Summit, 2023)

Figure 8: Attendance at the World Agri-Tech South America Summit 2023 alongside Mark Jarman (AgriTIERRA) and Federico Perez Wodtke (UK Department for Business and Trade, Argentina) (Source: Author)

5.2.2 Embrapa

Embrapa (see above), the Brazilian Agricultural Research Corporation, falls under the remit of the Brazilian Ministry of Agriculture and Livestock (MAPA), and aims to provide Brazil with food security and be a global leader in food, fibre and energy. Embrapa is guided by five key principles:

- Scientific excellence in agricultural research,
- Crops and livestock production efficiency and quality,
- Environmental sustainability
- Social aspects,
- Partnerships with the production sector.

During World Agri-Tech South America Summit week, Embrapa celebrated their 50th milestone, with representatives from across Embrapa congregating in São Paulo to discuss key highlights (Fig. 9).

Figure 9: Attendance at the Embrapa 50th milestone celebration (Source: Author)

This included recognition to all the below Embrapa units located throughout Brazil:

- Embrapa Acre
- Embrapa Agrobiology
- Embrapa Agroenergy
- Embrapa Agrosilvopastoral
- Embrapa Amapá
- Embrapa Beef Cattle
- Embrapa Cassava & Fruits
- Embrapa Cerrados
- Embrapa Coastal Tablelands
- Embrapa Cocais
- Embrapa Coffee
- Embrapa Cotton

- Embrapa Dairy Cattle
- Embrapa Digital Agriculture
- Embrapa Eastern Amazon
- Embrapa Environment
- Embrapa Fisheries and Aquaculture
- Embrapa Food Technology
- Embrapa Foods and Territories
- Embrapa Forestry
- Embrapa Genetic Resources & Biotechnology
- Embrapa Goats & Sheep
- Embrapa Grape & Wine
- Embrapa Instrumentation
- Embrapa Maize & Sorghum
- Embrapa Mid-North
- Embrapa Pantanal
- Embrapa Rice & Beans
- Embrapa Rondônia
- Embrapa Roraima
- Embrapa Semi-arid Region
- Embrapa Soils
- Embrapa Southeastern Livestock
- Embrapa Southern Livestock
- Embrapa Soybean
- Embrapa Swine & Poultry
- Embrapa Temperate Agriculture
- Embrapa Territorial
- Embrapa Tropical Agroindustry
- Embrapa Vegetables
- Embrapa Western Agriculture
- Embrapa Western Amazon
- Embrapa Wheat

Embrapa has been working closely with the UK Agri-Tech Centres, reviewing opportunities for cross fertilisation between the UK and Brazil Agri-Tech landscape.

5.2.3 UK Government in São Paulo

In country visits also included meetings with Laura Flaquer Moreira, Science and Innovation Network, and with Gabriela Meucci (Fig. 10), Department for Business and Trade for MH Government. These meetings were extremely valuable in understanding market needs, challenges, as well as opportunities for fostering better UK-Brazil collaborations.

Figure 10: Meeting with Gabriela Meucci (right), UK Department for Business and Trade, São Paulo (Source: Author)

6. Discussion

The aim of this project was to review the innovation landscapes of the USA and Brazil through a series of visits (see Section 5) to identify areas of collaboration for UK Agri-Tech. Each visit involved gathering both qualitative and quantitative data on the following topics:

1. Challenges facing agriculture in the respective country.
2. Development and adoption of innovation.
3. Opportunity for collaboration with the UK Agri-Tech ecosystem.

The aforementioned are discussed below:

6.1 Challenges Impacting Agriculture in the USA and Brazil

There are a wide range of challenges impacting agriculture in the USA, including, but not limited to:

- Rising input costs – e.g., energy, fuel, fertiliser and other supply costs.
- Supply chains - In 2021, President Biden issued Executive Order 14017 on America's Supply Chains which directed the Secretary of Agriculture to review the supply chains for the production of agricultural commodities and food products.
- USA monetary policy - Federal Reserve controls open market operations (OMO), interest rates and reserve requirements.
- Farm Bill - Members of Congress who are part of the Senate and House Committees on Agriculture, Nutrition, and Forestry are responsible for the Farm Bill covering topics such as commodities, conservation, nutrition, credit, rural development, R&D, forestry, energy, horticulture, crop insurance etc.
- Market dynamics – e.g., seasonality, production cycles, harvest timing, supply and demand dynamics, infrastructure impacts, weather, disease, external shocks, income levels, export demand, market conditions, inadequate storage/post-harvest losses, value chains, trade policies, policy/regulation, insurance schemes etc.
- Changing consumer behaviours – e.g., climate conscious, sustainability, urban produce, affordability, convenience, functional food, health conscious, pasture

raised meat/eggs, plant-based/novel proteins, reducetarian, gluten free, zero/low ABV beverages, botanicals, clean label etc.

- Regulations/regulatory reform/legislation – e.g., Clean Water Act, Clean Air Act, Endangered Species Act, Wetlands regulations; Federal Insecticide, Fungicide and Rodenticide Act, Food Safety Modernization Act, immigration and labour regulations, Federal Land Policy and Management Act etc.
- Infrastructure – e.g., affordable housing, secure power, rural connectivity, transportation infrastructure, clean water etc.
- Environmental challenges – e.g., climate change, wildfires, natural disasters, air pollution, deforestation, food waste, biodiversity loss, water pollution, ocean acidification, soil degradation, natural resources, acid rain, waste disposal, plastic pollution, invasive species, water scarcity etc.
- Emissions targets – President Biden signed the instrument to rejoin the Paris Agreement in January 2021.
- Lack of labour – e.g., impact of H-2A visa etc.
- Trade - e.g., Mexico to phase out the importation of biotech corn and agriculture products impacting USA trade.
- Inflation (i.e., up to 9.1% in June 2022)
- Politics
- Interest rates
- Tax reform
- Water regulation/water rights
- Right to repair
- Sustainability

Like the USA, Brazil faces many of the similar challenges as listed above (e.g., input costs, supply chain consumer behaviours, market dynamics, regulation, infrastructure, environmental challenges, emissions targets, labour, trade, inflation, political, tax, water rights, sustainability). Additional challenges noted during visits included:

- Deforestation – Impact of deforestation and the fires in the Amazon rainforest.
- Developing country - Brazil has a decreasing GDP per capita, high mortality and birth rates, with limited access to healthcare.

- Low ease of doing business – Brazil ranks 124th in the World Bank's global report which assesses ease of doing business, paying taxes, registering a business etc.
- Corruption – The Brazilian Government is working hard to reduce the level of corruption through the likes of the Clean Company Act.
- Cost of starting a business – High costs associated with permits, licenses, inscriptions, verifications at local, state, and federal level.
- Tax system – Brazil has one of the most complex tax systems in the world (e.g., VAT at federal, state, and municipal levels; ISS; PIS; COFINS; IPI).
- Exchange rate fluctuations
- Language barriers

6.2 Development and Adoption of Innovation

Despite the challenges listed in section 6.1 above, there was a relatively high level of adoption of Agri-Tech across large scale farms in both the USA and Brazil.

However, adoption, especially in smaller scale farms, remains a challenge. Barriers that were identified in this study included, but are not limited to:

- Lack of awareness
- Lack of training
- Lack of understanding regarding application
- Level of risk
- Scalability
- Interoperability
- Connectivity
- Cost / business model
- ROI
- Regulation / legislation
- Saturated market

Feedback that was gained during this study with regard to developing applicable Agri-Tech solutions, included:

- Need: Is the technology meeting a need? Technologies often focus on improving yields, increasing efficiency, or addressing the labour challenges, however, it is important these are qualified by the target customers.
- Value: Is the technology delivering value to the customer? Does the technology make life easier, or improve the profitability or productivity of the farm? Is the value being communicated in an appropriate way for the customer? What is the ROI for the farmer in purchasing the technology? What savings can the technology deliver? A Business Model Canvas (BMC) can provide the ideal strategic tool to review the value proposition, define and communicate a business idea or concept, and assess the nine fundamental elements of a business or product.
- Economics: Has the economics of the farm business been considered? Margins are often tight within farm businesses, and the financial health of a farm can be based on a previous or current growing season, as well as crop volatility.
- Interoperability: Is the technology aligned to current tools/approaches?
- Complexity: Can the technology be used within the current farm operation? Will adoption impact initial productivity? Are new skill sets required to operate the innovation? Is training provided? Is appropriate infrastructure in place for delivery?
- Farm size: Has the technology considered farm size? What is the ROI for a smaller farm enterprise?
- Crop diversity: Has the technology been developed for a single crop or animal, or can it be adopted across farm? Specialty crop equipment is a high-risk investment for farmers.
- Trust: This was noted as one of the most important factors. Whilst there may be a market for the new product, if there is no trust within the industry, then this will likely not equate to sales. This may involve working through advisors, dealers, and an effective communication and training strategy.

6.3 3. Opportunities for collaboration with the UK Agri-Tech ecosystem

All visits conducted as part of this study highlighted the fundamental importance of collaboration, both at national and international level. Further, it was stressed that a

multidisciplinary muti-stakeholder approach was essential in order to address the complex food, water, energy and climate challenges.

Potential areas of collaboration that were highlighted in this study included, but are not limited to:

Pre-farm gate:

- Seeds, seedling and plant genomics
- Animal genomics and breeding
- Raw materials marketplace
- Financial services

Farm gate:

- Monitoring/remote sensing/IoT/Data/Satellite data (e.g., sensors, drones, robotics, tractors, equipment for pests, diseases, weeds and nutritional deficiencies)
- Precision fertilizer/pesticides application
- Yield mapping
- Water management / Irrigation / Meteorology
- Waste management
- Environmental management / biodiversity / sustainability
- Novel pest, disease and weed control
- Soil health
- Improved efficiencies regarding sowing cultivation, harvesting, storage
- Improved grading
- Apiculture / pollination
- Data management / integrating platforms / Cybersecurity
- Connectivity / telecommunications
- Land / property management systems
- Educational / social media
- Rural community engagement
- Bio-energy / Renewable energy
- Urban agriculture / Controlled environment agriculture

- Animal health products

Post-farm gate:

- Novel foods and food trends
- Storage and logistics
- Food safety / Traceability / QC
- Bio-energy / Renewable energy
- Packaging systems / Recycling
- Retail management / Market place platforms
- Food processing
- Urban agriculture
- Honey processing

7. Conclusions

It can be concluded from this study that:

1. Collaboration and a multidisciplinary muti-stakeholder approach is essential to develop high impact game-changing Agri-Tech solutions to address global grand challenges.
2. There are a wider range of opportunities for Agri-Tech collaborations between the UK and the USA and Brazil to address pre and post farm gate challenges.
3. It is important to understand barriers to adoption, as well as fully review and understand the need, value, business model, economics, interoperability, market and complexity of new solutions.
4. Trust is essential for adoption.

8. Acknowledgements

I would like to thank my family for their continual support during my travels, and to my employer, Crop Health and Protection (CHAP) (Agri-Tech Centres), for their encouragement.

I would also like to record my thanks to the Trustees of The Farmers Club Charitable Trust who generously provided this opportunity, and to the selectors, who provided a rigorous selection process and excellent feedback.

My thanks are also due to all the contributors to this study, without which this report would not have been possible. Thank you for your time, patience and amazing hospitality! This includes all staff and students at the University of California Davis, University of California Merced, United States Department of Agriculture (USDA) - Agricultural Research Service (ARS), Embrapa, Department of Business and Trade Sao Paulo, Science and Innovation Network Sao Paul, British Consulate San Francisco and British Consulate Chicago.

Finally, thank you to all the farmers, research institutes, innovation networks, advisors, start-ups, accelerators and incubators who kindly donated their time to speak to me at the World Ag Expo, World Agri-Tech Innovation Summit and World Agri-Tech South America Summit. Without their insight, this report would not have been possible.

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10. Appendices

Appendix 1: AI driven project presented by UC Davis (Source: Artificial Intelligence Institute for Next Generation Food Systems)

Author/presenter	Project overview
Christine Diepenbrock	Developing an AI-enabled toolkit for routine integration of nutritional quality and aroma traits into molecular breeding strategies by Christine Diepenbrock. The aim of the project was to create predictors of nutritional quality/aroma from genetic and phenotypic features, and develop ML tools to evaluate the quality of new varieties based on their nutritional or aromatic molecular compositions.
Mason Earles	AgML: Open-Source Machine Learning Infrastructure pilot project with Optimized Sensor-driven Resilient Precision Agriculture by Mason Earles. The aim was to develop, characterize and test in real use conditions, novel inexpensive wireless sensors for accurately measuring soil nitrate as well as its fate and transport in the environment.
Nitin Nitin	Digital-Twin and Machine-learning enabled models for complex food manufacturing and nutrient delivery during digestion. The aim was to develop AI-enabled models for additive manufacturing of food for precision nutrition and AI-enabled digital twin of a gut digestion process to predict and optimize the bioaccessibility of micronutrients during digestion based on diverse composition and structure of foods.
Nitin Nitin	Project #7 Digital Twin and Machine-Learning for Optimized Pathogen Contact-tracing, Sanitation and Decontamination. The aim was to develop Digital Twin and Machine Learning algorithms for addressing key food safety challenges associated with introduction and spread of pathogens in food facilities and enable guided decontamination for food contact surfaces to reduce risk of cross-contamination.
Steve Brown	Improving tomato quality and safety by AI-driven supply chain optimization and AI prediction of losses at specific stages. The aim was to build the framework for overall AI-driven supply