Transformative Agtech and Sustainability Challenges

Part 2: Field sensors and crop drones driving farming efficiency

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Published on August 9, 2021

Contents

Key takeaways

- Agricultural industrialization and the concurrent focus on short-term productivity gains have created long-term sustainability issues that threaten the environment, human health, and farm fertility.
- Emerging technologies including biotech feed additives, field monitoring and analysis tools, and advanced farm equipment are mitigating agricultural pollution challenges.
- Innovative irrigation solutions, indoor farming strategies, and ag biotech inputs are helping agricultural operations adapt to drought and climate change.
- Farms are tackling food waste challenges by identifying new e-commerce sales channels, deploying robotics and automation to perform agricultural tasks, and optimizing farm planning and management with new software tools.
- Healthy soil is essential for productive crops and a key tool in sequestering carbon emissions and mitigating climate change. Industrial agriculture practices such as the overuse of chemical pesticides and fertilizers threaten to render topsoil infertile, harming farm productivity and hindering the environmental benefits of healthy soil.

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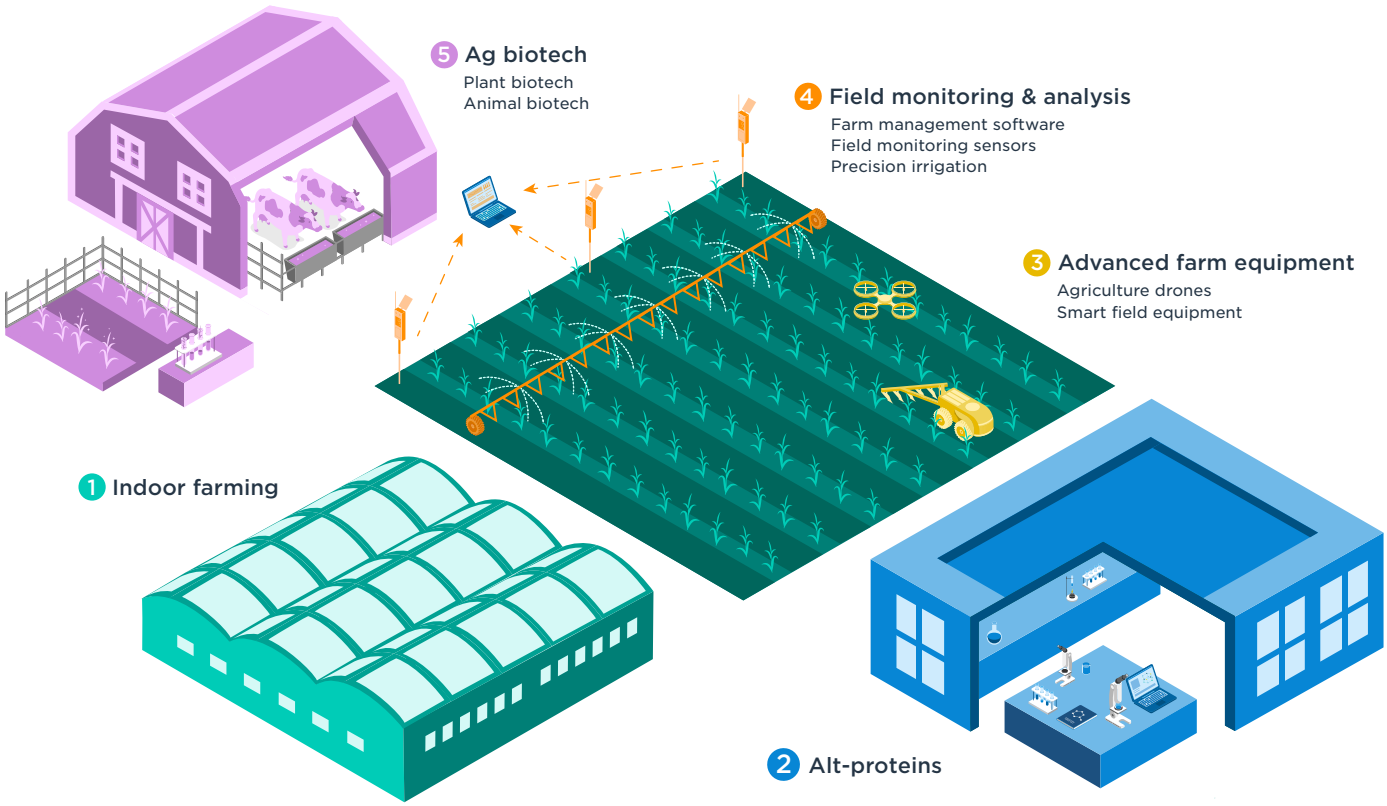
Overview

For more information on food supply systems, please see part one in this series, the PitchBook Q2 2021 Analyst Note: Journey to a More Sustainable Food System.

This note is part two of a five-part series examining the most prevalent sustainability challenges affecting modern food supply systems and the technologies being developed to address them. This installment focuses on the sustainability challenges facing farmers and the emerging technologies transforming the agriculture industry.

Technological innovation over the past 100 years has been critical in increasing farm productivity to meet the demands of a growing population. However, agricultural industrialization and the concurrent focus on short-term productivity gains have created long-term sustainability issues that affect the environment, human health, and farm fertility. These issues include pollution in the form of greenhouse gas (GHG) emissions and fertilizers, drought and water scarcity, food waste, and soil degradation.

An overview of the agtech industry



While these challenges can sometimes seem insurmountable, the agtech industry is leading the way in developing products and solutions to help farmers address sustainability challenges and adapt to changing environments. Some of the more transformative areas of agtech innovation include indoor farming, which can dramatically improve resource efficiency; alt-proteins, which can reduce GHGs; automated field robotics and drones, which can improve farm productivity and soil health; and advances in biotech such as microbial biochemicals and mRNA pesticides, which are leading to the development of safer fertilizers and more resilient crops.

Sustainability challenge 1: Pollution

GHG emissions: GHGs are man-made—or livestock-made—gases such as carbon dioxide, nitrous oxide, and methane that contribute to climate change when released into the atmosphere. It is commonly understood that GHG emissions come from manufacturing, energy production, and transportation. However, the agriculture industry is also a significant generator of emissions. According to the World Resources Institute's Climate Analysis Indicators Tool (CAIT), as of 2018, agriculture activities accounted for 12% of total GHG emissions globally and are the leading contributor of methane at 42% and nitrous oxide at 75%.[1]

GHGs lead to increasingly frequent extreme weather events such as flooding and droughts, which damage crop yields, reduce water retention in aquifers, and create tension between farmers and residential communities. GHGs also contribute to more lasting changes in climate such as the aridification of the Western US, which poses a permanent threat to agriculture.

The largest emitter of methane is enteric fermentation—colloquially known as "cow farts." This is part of the digestive process of ruminant animals, such as cattle and sheep.[2] While innovative farming practices such as livestock feed additives can reduce emissions per cow, enteric fermentation is a core aspect of ruminant digestion. Therefore, its elimination relies on removing or replacing ruminant livestock agriculture.

Manure from livestock and poultry contributes an estimated 3% of total global methane emissions as of 2020.[3] Emissions can be reduced using anaerobic digesters that capture the methane and convert it into biofuel. Alternatively, some startups derive utility from manure by upcycling it into fertilizer or other agricultural inputs.

Chemical misuse: Improper use of nitrogen fertilizer is another key cause of pollution and a significant expense for farmers. Nitrogen pollution comes in the form of gas or liquid and can negatively affect the environment, human health, and the economy. Rain and snowmelt can cause fertilizer runoff into waterways and leach into groundwater. This runoff leads to excess nutrients in the water, known as "eutrophication," which can cause significant algae growth that can produce harmful toxins and reduce water oxygen levels, affecting aquatic plants and animals. Overuse of nitrogen fertilizer also converts to GHG nitrous oxide and eventually, ammonia and ozone, which are harmful to both human life and aquatic life and contribute to climate change. Lastly, overuse of ag chemicals poses a threat to ag workers and consumers and can lead to pest and disease resistance.

1: "Historical GHG Emissions," Climate Watch, accessed June 24, 2021.
2: "Global Methane Emissions and Mitigation Opportunities," Global Methane Initiative, accessed on June 24, 2021.
3: Ibid.

Emerging pollution mitigation technologies

A variety of emerging solutions focus on reducing fertilization-linked pollution. These include sustainable farming practices such as cover crops, irrigation management, buffer crops, and nutrient management techniques. In addition, startups are developing fertilizer alternatives and farm management equipment to reduce the need for fertilizer. Specific products include:

Animal feed additives: Minimizes methane production in ruminant animals, thereby reducing harmful GHGs. Key VC-backed providers include Blue Ocean Barns, CH4 Global, and ZELP.

Plant microbial inputs: Replaces synthetic fertilizers and pesticides with microbes and bacteria-based treatments that mitigate harm to soil and marine health. Key VC-backed providers include Pivot Bio, AgBiome, and NewLeaf Symbiotics.

Advanced farm equipment: Uses advanced sensors, computer vision, drones, and smart field machinery to deploy crop treatments with high precision, minimizing waste and runoff. Key VC-backed providers include Tortuga Agtech, American Robotics, and Tevel.

Field monitoring & analysis tools: Includes in-field sensors and farm management software that track several crop, soil, and environmental variables. Key VC-backed providers include Ganaz, Semios, and HydroPoint.

Waste treatment & upcycling: Includes waste capture and water reclamation solutions that capture agricultural contaminants, which are converted into fertilizer, clean water, and energy. Key VC-backed providers include Digested Organics, BHSL Hydro, and N2 Applied.

Emerging solutions for pollution challenges

Mitigation technologies	Startups		
Animal feed additives	Blue Ocean Barns	CH4 Global Zero Methane Agriculture	zelp
Plant microbial inputs	Pivot Bio	AgBiome	NewLeaf symbiotics
Advanced farm equipment	Tortuga AgTech	American Robotics	Tevel
Field monitoring & analysis tools	Ganaz	semios	HydroPoint
Waste treatment & upcycling	Digested Organics	BHSL Waste Solutions	N2 Applied

Source: PitchBook | **Geography:** Global

Sustainability challenge 2: Drought and water scarcity

Water shortages pose a significant threat to agriculture as well as human and animal health. Although many factors contribute, shortages are primarily tied to poor management, outdated infrastructure, drought, and shifting climates.

Droughts have large economic impacts on agriculture and consumer prices. NOAA Climate.gov estimates that US droughts have caused economic damage totaling $249.7 billion across 26 drought events since 1980. The average economic cost is estimated at $9.6 billion per drought event.[4] We expect that the economic cost will continue to grow as climate change causes more frequent and severe droughts.

Key factors affecting the supply and demand of water

Climate change: One of the leading issues affecting water supply is climate change. Shifting climates are exacerbating weather issues globally. Drought leaves farmers in the US and other regions with too little water to grow crops, while palm-oil orchards and rice paddies in Southeast Asia experience severe flooding. These extreme weather events are projected to get worse. Some climate experts believe the lack of water in the Western US is aridification, a permanent state of dry weather, as opposed to drought, which is temporary or cyclical.

Outdated infrastructure: The Western US is characterized by rain and snow in the winter months and minimal precipitation the rest of the year. Water storage projects including dams help capture precipitation and snowmelt in wetter months for use in dry months. Many dams and water storage projects in the US were built during the first half of the 20th century. In the following decades, population growth, increased agriculture activity, and shifting climates have led to water demand that is greater than supply.

Mediocre water management: Agriculture is the largest global user of freshwater, with practices consuming 70% of freshwater extraction from rivers and groundwater.[5] One reason for this is that older irrigation techniques such as gravity irrigation contribute to excess water loss and runoff. Modern practices such as low-pressure drip irrigation increase application precision and minimize runoff and extended soil saturation.[6]

Growing populations and urban sprawl: Population growth, especially in the Western US where water is in limited supply, exacerbates water demand issues and pits farmers and municipalities against each other. California's population has nearly quadrupled since 1950, taxing water supply and overwhelming antiquated infrastructure.

4: "2010-2019: A Landmark Decade of US Billion-Dollar Weather and Climate Disasters," NOAA Climate.gov, Adam B. Smith, January 8, 2020.
5: "Domestic Water Use Grew 600% Over the Past 50 Years," World Resources Institute, Betsy Otto and Leah Schleifer, February 10, 2020.
6: "Conservation Practices That Save: Irrigation Water Management," USDA, Accessed June 25, 2021.

Outdated regulations: Outdated water regulations make water issues worse by allocating more water than is available. For example, the Colorado River Compact signed in 1922 gave seven states in the Colorado River Basin access to more water than what is available in the river, resulting in the repeated depletion of water reservoirs throughout the years.

Shift to water-intensive crops: Farming is a low-margin business. As such, farmers are continually searching for new tools, technologies, and crops that will increase profits, often without consideration for water demand. Almonds and avocados are two such high-margin crops that are also highly water intensive. While precision irrigation helps some farmers reduce water needs, other farmers have been forced to rip out trees.

Effects of drought on farming sustainability

Fallowed land and ruined crops: Without sufficient water supply to grow crops for harvesting, farmers are forced to make difficult decisions such as abandoning acres of farmland to conserve water for smaller crops. These changes reduce farm productivity by threatening food supply and the ability to feed livestock such as dairy cows and sheep. These changes also result in elevated consumer prices for agricultural goods.

Reduction in water-intensive tree crops: Some tree crops, such as citrus, avocados, and almonds, have high water needs and are especially sensitive to dry conditions. Water constraints lead some farmers to replace older trees with younger trees that tend to consume less water. Other farmers are switching altogether to crops that are less resource intensive.

Increased groundwater pumping: Farms with shrinking access to river water for irrigation are increasingly pumping groundwater, thereby depleting aquifers and water availability. Excessive pumping and aquifer depletion leads to subsidence, or land sinking, which causes a permanent loss of groundwater storage and increases flooding risk.

Threats to small farms: Weathering a drought requires deep pockets or government aid to survive the financial challenges of poor growing seasons. Smaller farms have less access to capital and lobbying resources and are likely to fare much worse over the long term, necessitating a shift to fewer and larger farming operations and increased costs for consumers.

Emerging drought adaptation technologies

Drought adaptation technology generally falls into two categories: technologies that help farmers conserve water and technologies that make crops more resilient and better able to withstand extreme weather events. Key technologies include:

Irrigation tools: These monitor and manage precision irrigation. Key VC-backed providers include Hortau, Farm(x), and WaterBit.

Ag biotech inputs: One example is microbial fertilizers. Key VC-backed providers include Native Traits, BioPrime AgriSolutions, and NewLeaf Symbiotics.

Indoor farming: Controlled environment ag is the most drastic intervention. By bringing farming operations indoors, farmers can utilize water-efficient growing methods such as hydroponics and aeroponics. Key VC-backed providers include Freight Farms, Red Sea Farms, and TruLeaf.

Emerging solutions for drought and water scarcity

Mitigation technologies	Startups
Irrigation tools	HORTAU, farm(x), WaterBit
Ag biotech	Native Traits, BioPrime AgriSolutions Pvt Ltd, NewLeaf symbiotics
Indoor farming	FREIGHT FARMS, RED SEA FARMS, TruLeaf Farming. Anywhere.

Source: PitchBook | **Geography:** Global

Sustainability challenge 3: Food waste

Farm-level food waste is defined as food intended for human consumption that is either never harvested or never sold. Food waste is a critical sustainability issue that negatively affects food security, resource availability, and even climate change. Food often goes to waste for economic reasons—commodity prices are too low, or the cost of labor to pick, pack, and ship may be too high to generate a profit. Food may also go to waste due to physical imperfections such as damage from harvest machinery, disease, or pests.

A recent study found that 33.7% of edible produce went unharvested in fields.[7] The economic cost of wasted food in the US was estimated at $285.0 billion in 2019, and 21% of that figure can be attributed to farm waste.[8] Aside from the cost of wasted food, sizeable environmental impacts also exist—for example, GHG emissions as well as unharvested produce left on the field and the water needed to sustain it. In 2019, the 13.9 million tons of food left unharvested in the US was estimated to generate 620,168 tons of CO2eq and waste 818,145 million gallons of water.[9] Addressing key challenges leading to food waste on the farm will likely provide significant economic and environmental utility.

Emerging food waste reduction technologies

Food waste reduction solutions focus on better matching the supply and demand of agricultural goods by identifying new markets, addressing productivity challenges, and optimizing farm planning and management. Specific solutions include:

New e-commerce sales channels: Increased consumer awareness regarding food waste has created a grassroots demand for imperfect and surplus produce. New marketplaces and e-commerce startups have formed to cater to that demand. Emerging models include imperfect produce boxes such as Imperfect Foods and B2B marketplaces such as Full Harvest that cater to companies such as juice providers that consider cosmetic imperfections unimportant. Upcycling is another vehicle to salvage agricultural goods that may otherwise go to waste. Key VC-backed providers include Imperfect Foods, Full Harvest, and Comet Bio.

Robotics & automation: Labor shortages are driving up the cost and availability of labor to harvest fields and perform other key tasks. Farm robotics and automation are emerging as a solution to increase productivity and counter labor challenges. Farm robots provide an ever-expanding list of functions including seeding, spraying, picking, and shuttling crops from the field. Key VC-backed providers include TerraClear, Harvest Automation, and Tortuga AgTech.

7: "On-Farm Food Loss in Northern and Central California: Results of Field Survey Measurements," Gregory A. Baker et al., *Resources Conservation & Recycling*, July 3, 2019.
8: "What Is Food Waste?" ReFED, Accessed June 30, 2021.
9: "ReFED Insights Engine," ReFED, January 22, 2021.

Farm management software: Sources of surplus food often tie back to inaccuracies in forecasting commodity prices and crop demand. Farm management tools utilize machine learning and forecasting tools to provide farmers with insights to help choose the crops and quantity that will minimize risk and maximize profit. Some software platforms have labor management tools designed specifically for agricultural workers to maximize retention. Key VC-backed providers include Ganaz, Gro Intelligence, and IntelinAir.

Emerging solutions for food waste

Mitigation technologies	Startups		
New e-commerce sales channels	Imperfect Foods	Full Harvest	CometBio
Robotics & automation	TerraClear	Harvest Automation	Tortuga AgTech
Farm management software	Ganaz	Gro Intelligence	intelinair

Source: PitchBook | **Geography:** Global

Sustainability challenge 4: Soil degradation

Healthy soil is essential for productive crops and a key tool in sequestering carbon emissions and mitigating climate change. Soil is not just an inert growth medium; it is an entire ecosystem containing billions of microbes, fungi, and bacteria that perform vital agricultural activities such as converting organic matter into nutrients, filtering pollutants, storing water for dry periods, and providing roots with stability.[10] Aside from its agricultural benefits, healthy soil plays a vital role in storing atmospheric carbon. US agricultural soils are estimated to be able to sequester 10% of annual US carbon emissions if managed properly.[11] Many common industrial agricultural practices negatively affect soil health.

Soil degradation is a complex and large-scale issue affecting farms globally. The potential impact is challenging to measure due to the diversity of soil types and quality, weather impacts, and land management style. Some experts such as Maria-Helena Semedo of the UN Food and Agriculture Organization have stated that global topsoil will have eroded entirely in 60 years due to current degradation rates.[12] However, minimal evidence supports this claim. A more realistic estimate posits that globally, 16% of conventionally managed farmed soils have a lifespan of fewer than 100 years before topsoil is fully eroded, rendering the land infertile.[13] Globally, the top 10 most produced crops by metric tons[14] have an annual gross production value of $865.3 billion.[15] Assuming that 95% of farmland is conventionally managed, the financial loss could top $131.5 billion annually.

Causes of soil degradation

Synthetic pesticides and fertilizers: Synthetic fertilizer is a critical innovation that has allowed for monumental increases in crop productivity in the 20th century. Today, produce grown using synthetic fertilizer feeds roughly half the global population.[16] However, using synthetic inputs comes at a cost. Adding nitrogen fertilizer to soil disrupts the natural process of microorganisms breaking down organic matter to produce nitrogen and carbon naturally.[17] With synthetic fertilizer, each crop cycle requires more nitrogen to produce the same yield. Long-term application of synthetic fertilizers and pesticides has been shown to disrupt microorganisms, reducing soil organic matter and nutrient availability.[18] Overapplication of synthetic inputs leads to higher chemical usage and the degradation of soil quality. Regenerative farming practices such as the use of cover crops are

10: "Soil Health," USDA, Accessed June 29, 2021.
11: "Biden Wants To Pay Farmers To Grow Carbon-Capturing Crops. It's Complicated," *Politico*, Helena Bottemiller Evich and Ryan McCrimmon, June 29, 2021.
12: "Only 60 Years of Farming Left if Soil Degradation Continues," *Reuters*, Chris Arsenault, December 5, 2014.
13: "Soil Lifespans and How They Can Be Extended by Land Use and Management Change," *Environmental Research Letters*, D. L. Evans, et al., September 15, 2020.
14: Sugarcane, maize, wheat, potatoes, soybeans, cassava, oil palm fruit, tomatoes, barley, and bananas.
15: "Value of Agricultural Production," Food and Agriculture Organization of the United Nations, Accessed June 29, 2021.
16: "Fertilizers," Our World in Data, Max Roser and Hannah Ritchie, 2013.
17: "It's Time To Put Our Soils First. Long-Term Global Food Production Depends on It," *Entrepreneur Magazine*, Brian Maxted, June 29, 2021.
18: "Assessment of Soil Health in Urban Agriculture: Soil Enzymes and Microbial Properties," *Sustainability*, Avanthi Deshani Igalavithana, et al., February 20, 2017.

an effective way to improve soil health. Yet, these practices likely come at the cost of productivity. Biochemicals such as microbial treatments fertilize crops and build resiliency, providing a viable alternative to synthetic inputs.

Monocropping: This practice of growing the same crop repeatedly on the same land contrasts with polyculture, where multiple crop species are grown on the same plot, and rotational cropping, where the crop species are rotated regularly. Monocropping is popular because it allows farmers to continuously pursue the most profitable crops. However, in the long term, monocropping causes issues including:

- Decrease in beneficial microbes in the soil, hindering plant productivity
- Depletion of soil nutrients, necessitating fertilizer use
- Decrease in soil organic matter, reducing soil structure and potentially leading to erosion
- Increase in pests and disease, leading to additional pesticide and fungicide use

Excessive tilling & heavy machinery: The use of increasingly heavy farm machinery leads to soil compaction, which decreases aeration and water absorption and leads to poor plant growth and water runoff. Tilling is a common agricultural practice of mechanical soil agitation to add air and organic matter in preparation for planting, but it has long-term adverse effects on soil health and the environment. A layer of compacted soil—called a plow pan—is created, limiting water and root penetration. Tilling causes surface runoff and soil erosion that damages soil fertility and increases vulnerability to drought. From a climate change perspective, tilling also releases soil-sequestered carbon into the atmosphere.

Emerging soil degradation mitigation technologies

A variety of emerging solutions are improving or mitigating damage to soil. These include less-detrimental farm machinery, in-field sensors to collect data and improve decision-making, environmentally friendly ag inputs, and innovative economic models that incentivize soil-friendly ag practices. Key technologies include:

Drones & automated farm equipment: Drones and smaller, lighter automated farm machinery are increasingly capable of performing the same tasks as heavy farm machinery. The reduced reliance on heavyweight machinery reduces soil compaction issues. Key VC-backed providers include Guardian Agriculture, Four Growers, and HarvestX.

Precision farming: Tools such as imagery analytics services and in-field sensors gather soil data and create granular maps to prescribe precision treatments, minimizing waste. Key VC-backed providers include Farm(x), Sentera, and GroGuru.

Biofertilizers: Innovative alternatives to chemical fertilizers utilize bacteria, microbes, and other less harmful ingredients to add nutrients to soil while mitigating negative environmental effects. Key VC-backed providers include PivotBio, Vestaron, and Micropep Technologies.

Soil carbon markets: Regenerative farming practices are a collection of sustainable farming activities that sequester carbon in the soil. Farmers may avoid these practices because they can be more labor intensive or less profitable in the short term when compared to conventional practices. Soil carbon markets create a demand for GHG emissions that incentivize farmers to pursue regenerative farming practices that trap carbon, which is then sold to governments or companies to meet carbon reduction targets. Various organizations, including VC-backed startups, have started markets. Still, the industry is nascent and major barriers remain, such as how to measure sequestered carbon, which farming practices are most effective, and what types of policies and oversights are needed. Key VC-backed providers include Indigo Ag, Nori, and CiBO Technologies.

Emerging solutions for soil degradation

Mitigation technologies	Startups
Drones & automated farm equipment	Guardian Agriculture, Four Growers, HarvestX
Precision farming	farm(x), sentera, groguru
Biofertilizers	Pivot Bio, Vestaron, micropep technologies
Soil carbon markets	indigo, Nori, CiBO Technologies

Source: PitchBook | **Geography:** Global

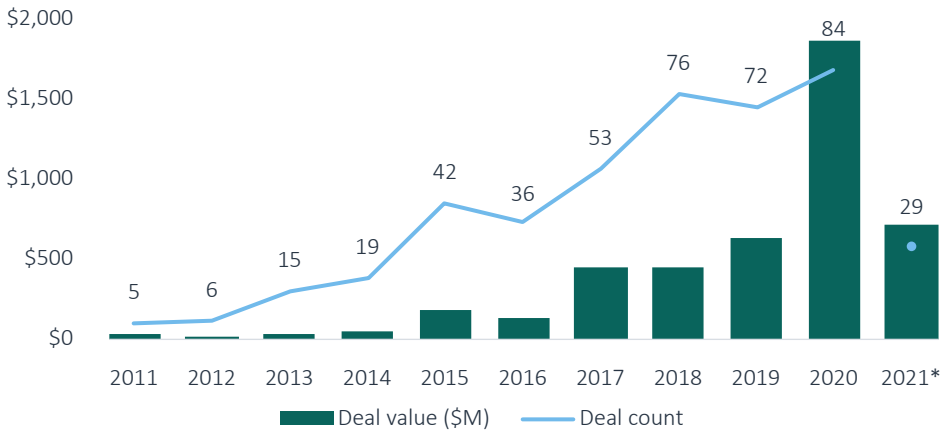
Leading agtech technologies

Indoor farming

Also referred to as "controlled environment agriculture," this method of growing crops indoors uses advanced technologies to control environmental factors including light, water, temperature, humidity, and nutrients. Indoor farming is an attractive farming strategy because it is vastly more resource efficient than conventional outdoor farming. Farmers can precisely administer inputs with minimal water and nutrient waste. Indoor farming is adaptable, flexible, and can reduce sources of food waste. The strategy mitigates waste challenges including overuse of water as well as pollution from chemicals and synthetic fertilizers. It also adapts to worsening climate change effects such as extreme weather events and water scarcity. Key VC-backed providers include Plenty, Revol Greens, and Upward Farms.

For more information on indoor farming, please see the PitchBook Q1 2021 Analyst Note: Cultivating Opportunities in Indoor Farming.

VC deal activity in indoor farming



Source: PitchBook | **Geography:** Global
*As of June 17, 2021

Top 10 VC-backed indoor farming companies*

Company	VC raised to date ($M)	Most recent pre-valuation ($M)	Most recent deal type	HQ location
Plenty	$541.0	N/A	Late-stage VC	San Francisco, California, US
Bowery Farming	$487.5	$2,000.0	Late-stage VC	New York, New York, US
Infarm	$429.4	N/A	Late-stage VC	Berlin, Germany
Revol Greens	$215.0	N/A	Early-stage VC	Owatonna, Minnesota, US
AeroFarms	$214.5	N/A	Late-stage VC	Newark, New Jersey, US
BrightFarms	$212.9	$145.0	Late-stage VC	Irvington, New York, US
Gotham Greens	$129.9	N/A	Late-stage VC	New York, New York, US
Little Leaf Farms	$90.0	N/A	Late-stage VC	Devens, Massachusetts, US
Pure Harvest Smart Farms	$89.3	N/A	Late-stage VC	Abu Dhabi, United Arab Emirates
Shenandoah Growers	$87.0	N/A	Late-stage VC	Harrisonburg, Virginia, US

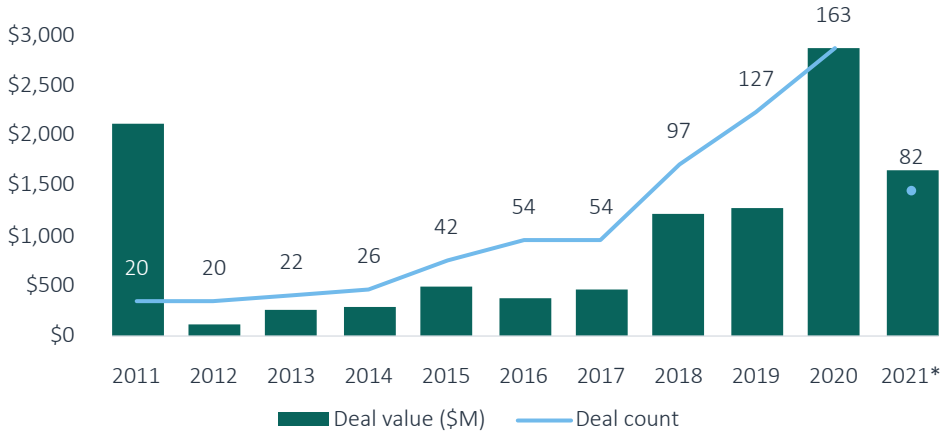
Source: PitchBook | **Geography:** Global
*As of June 17, 2021

For more information on alt-proteins, please see the PitchBook Q3 2021 Analyst Note: Reinventing Meat.

Alt-proteins

Alternative proteins—or alt-proteins—consist of meat, seafood, dairy, and egg products that are synthesized in factories from plants, animal cells, microbes, or fungi. Producing alt-proteins may generate lower GHG emissions and require less land than conventional meat production. Although a one-for-one replacement of conventional meat with alt-proteins would likely lead to significant environmental benefits, it is unlikely in the long term due to the many industries reliant on animal products. Key VC-backed alt-protein providers include Eat Just, Perfect Day, and Motif FoodWorks.

VC deal activity in alt-proteins



Source: PitchBook | **Geography:** Global
*As of June 17, 2021

Top 10 VC-backed alt-protein companies*

Company	VC raised to date ($M)	Most recent pre-valuation ($M)	Most recent deal type	HQ location
Impossible Foods	$1,362.5	$5,000.0	Late-stage VC	Redwood City, California, US
Eat Just	$736.5	N/A	Late-stage VC	San Francisco, California, US
Perfect Day	$361.5	$500.0	Late-stage VC	Emeryville, California, US
Motif FoodWorks	$343.5	N/A	Early-stage VC	Boston, Massachusetts, US
LIVEKINDLY	$342.5	$885.0	Early-stage VC	Los Angeles, California, US
Bolt Threads	$214.3	$615.0	Late-stage VC	Emeryville, California, US
UPSIDE Foods	$208.2	$363.8	Early-stage VC	San Leandro, California, US
Ripple Foods	$164.4	$130.0	Late-stage VC	Berkeley, California, US
Calysta	$133.7	$200.0	Late-stage VC	Menlo Park, California, US
MycoTechnology	$130.9	$225.0	Late-stage VC	Aurora, Colorado, US

Source: PitchBook | **Geography:** Global
*As of June 17, 2021

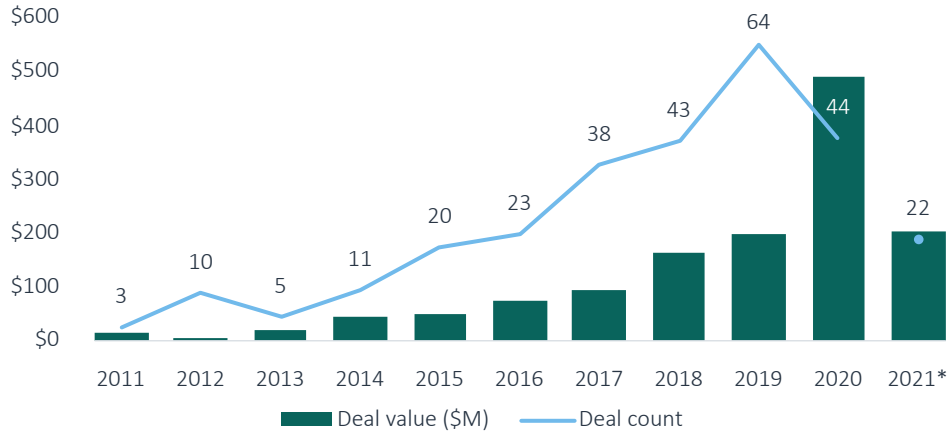
Advanced farm equipment

Innovations in farm machinery address labor challenges, enable precision farming tasks, and mitigate a host of sustainability challenges including soil compaction, GHG emissions, chemical runoff, and food waste. We segment advanced farm equipment into two categories:

Agriculture drones: Industrial drones can perform key agricultural tasks such as seeding, spraying, and surveying. Benefits of drones include autonomous operation, speed, extreme accuracy, and aerial perspective. In terms of sustainability, drones reduce reliance on labor constraints, minimize input waste, and reduce soil compaction. Downsides of drone usage include regulatory constraints, smaller payload capacity in comparison to conventional machinery, and complexity of use that may require hiring experts to operate the drone. Key VC-backed providers include Xaircraft, American Robotics, and Tevel.

Smart field equipment: This equipment innovates on existing farm machinery by adding the ability to electrify, automate, and perform other technical functions such as harvest vine crops. Smart equipment tends to be smaller than conventional machinery, facilitating tighter navigation among row crops. Benefits include reduced soil compaction, mitigated risk of food waste due to labor constraints, and reduced GHG emissions due to electrification. Key VC-backed providers include TerraClear, Harvest Automation, and Tortuga AgTech.

VC deal activity in advanced farm equipment



Source: PitchBook | **Geography:** Global
*As of June 17, 2021

Top 10 VC-backed advanced farm equipment companies*

Company	VC raised to date ($M)	Most recent pre-valuation ($M)	Most recent deal type	HQ location
Xaircraft	$246.2	N/A	Late-stage VC	Guangzhou, China
Clearpath Robotics	$82.0	N/A	Late-stage VC	Kitchener, Canada
Percepto	$64.2	$27.5	Lat-stage VC	Modi'in-Maccabim-Re'ut, Israel
FJ Dynamics	$60.9	N/A	Early-stage VC	Nanjing, China
Blue Ocean Robotics	$57.0	N/A	Late-stage VC	Odense, Denmark
Soft Robotics	$54.3	$90.0	Late-stage VC	Bedford, Massachusetts, US
Plus One Robotics	$43.6	$70.0	Late-stage VC	San Antonio, Texas, US
Harvest Automation	$33.6	$38.9	Late-stage VC	Billerica, Massachusetts, US
TerraClear	$31.6	$58.0	Early-stage VC	Bellevue, Washington, US
ecoRobotix	$28.4	$23.3	Late-stage VC	Yverdon-les-Bains, Switzerland

Source: PitchBook | **Geography:** Global
*As of June 17, 2021

Field monitoring & analysis

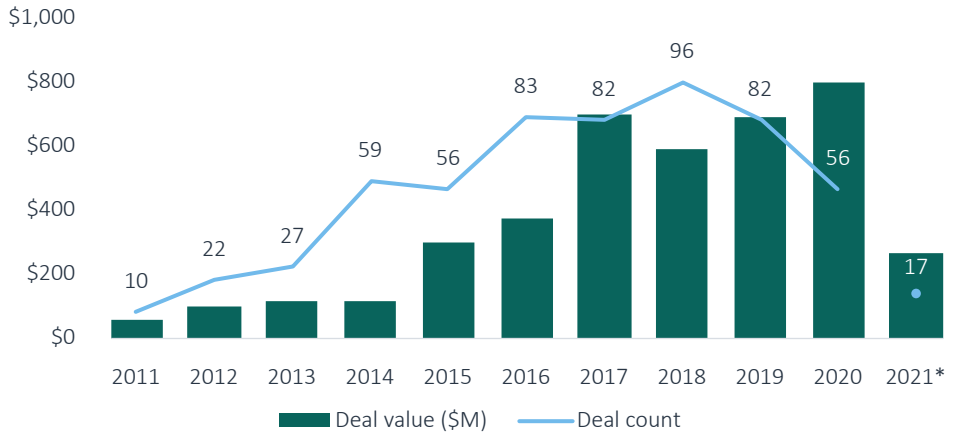
These technologies consist of software and hardware tools to manage and monitor farm conditions, as well as predictive analytics tools to improve decision-making. We segment field monitoring & analysis technologies into three categories:

Farm management software: This software provides farmers with actionable insights relevant to farm management by gathering and analyzing data across the farm and beyond. Examples of data points include crop conditions, labor, weather, and economy such as demand and commodity prices. Sustainability benefits include mitigated risk of food waste and reduced resource consumption. Key VC-backed providers include Ganaz, Gro Intelligence, and IntelinAir.

Field monitoring sensors: More targeted than farm management software, these sensors typically consist of multisensor hardware units affixed in-field or on tree crops and a software platform to manage collected data. To maximize crop health and productivity, gathered field data points include weather, pest pressure, water conditions, and plant stress. Field monitoring sensors mitigate the risk of food waste and reduce resource consumption. Key VC-backed providers include Semios, Arable, and The Yield.

Precision irrigation: These systems and tools help manage usage by monitoring soil moisture or soil tension and may automatically supply water to fields when moisture levels are low. Some irrigation systems are solar powered, reducing reliance on fossil fuels. Sustainable benefits include reduced resource consumption, erosion, chemical runoff, and GHG emissions. Key VC-backed providers include Hortau, WaterBit, and HydroPoint.

VC deal activity in field monitoring & analysis



Source: PitchBook | **Geography:** Global
*As of June 17, 2021

Top 10 VC-backed field monitoring & analysis companies*

Company	VC raised to date ($M)	Most recent pre-valuation ($M)	Most recent deal type	HQ location
Farmers Business Network	$619.3	$1,600.0	Late-stage VC	San Carlos, California, US
Planet	$365.5	N/A	Late-stage VC	San Francisco, California, US
Spaceflight Industries	$225.5	N/A	Late-stage VC	Seattle, Washington, US
Orbital Insight	$203.7	$250.0	Late-stage VC	Palo Alto, California, US
DroneDeploy	$150.0	$450.0	Late-stage VC	Santa Clara, California, US
PrecisionHawk	$138.7	N/A	Late-stage VC	Raleigh, North Carolina, US
Satellogic	$129.3	N/A	Late-stage VC	Montevideo, Uruguay
Gro Intelligence	$109.4	N/A	Late-stage VC	New York, New York, US
Semios	$101.6	N/A	Late-stage VC	Vancouver, Canada
Capella Space	$97.0	$165.0	Early-stage VC	San Francisco, California, US

Source: PitchBook | **Geography:** Global
*As of June 17, 2021

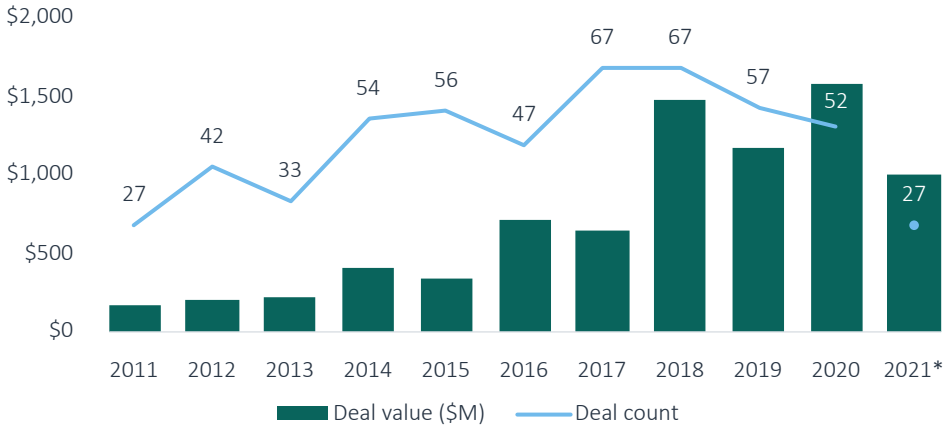
Ag biotech

Biotech providers play an important role in mitigating sustainability challenges and adapting to the effects of climate change. We segment the sector into two categories:

Plant biotech: Providers develop biological or chemical products including custom plants, organisms, fertilizers, and other transgenic inputs. Sustainability-focused solutions include beneficial bacterial and microbial treatments that feed nitrogen to crops without synthetic chemicals that harm the soil and marine health. Other agricultural products deter pests without chemicals harmful to the environment and human health. Some providers are developing new species and treatments that protect crops against climate change effects such as insect or water stress. Key VC-backed providers include Terramera, Pivot Bio, and Provivi.

Animal biotech: Providers develop solutions that address animal genetics through genetic engineering, modification, and cloning; sustenance through feed additives and feedstuffs; breeding through fertility treatments; and health through nutrition and health-optimizing products. A subset of providers is currently developing feed additives that minimize methane production in ruminant animals. Benefits of animal biotech include a reduction in GHG emissions and food waste due to fewer sick animals. Key VC-backed providers include Blue Ocean Barns, CH4 Global, and ZELP.

VC deal activity in ag biotech



Source: PitchBook | **Geography:** Global
*As of June 17, 2021

Top 10 VC-backed ag biotech companies*

Company	VC raised to date ($M)	Most recent pre-valuation ($M)	Most recent deal type	HQ location
Indigo Ag	$1,116.6	$2,250.0	Late-stage VC	Boston, Massachusetts, US
Inscripta	$459.5	$1,150.0	Late-stage VC	Boulder, Colorado, US
Inari	$352.0	$1,000.0	Late-stage VC	Cambridge, Massachusetts, US
DNAnexus	$307.7	$219.3	Late-stage VC	Mountain View, California, US
GreenLight Biosciences	$261.1	N/A	Late-stage VC	Medford, Massachusetts, US
Provivi	$192.2	$201.0	Late-stage VC	Santa Monica, California, US
Pivot Bio	$186.7	$310.0	Late-stage VC	Berkeley, California, US
Cool Planet	$169.6	N/A	Late-stage VC	Greenwood Village, Colorado, US
Caribou Biosciences	$156.0	$265.0	Late-stage VC	Berkeley, California, US
AgBiome	$119.0	N/A	Late-stage VC	Durham, North Carolina, US

Source: PitchBook | **Geography:** Global
*As of June 17, 2021