

MOISTURE

MODERATE

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AI-driven Food Systems to Sustainably Nourish the World

Ranveer Chandra

We need to increase food production and decrease environmental impact



Over **820 million** people worldwide suffer from hunger



More than **2 billion** people lack vital nutrients



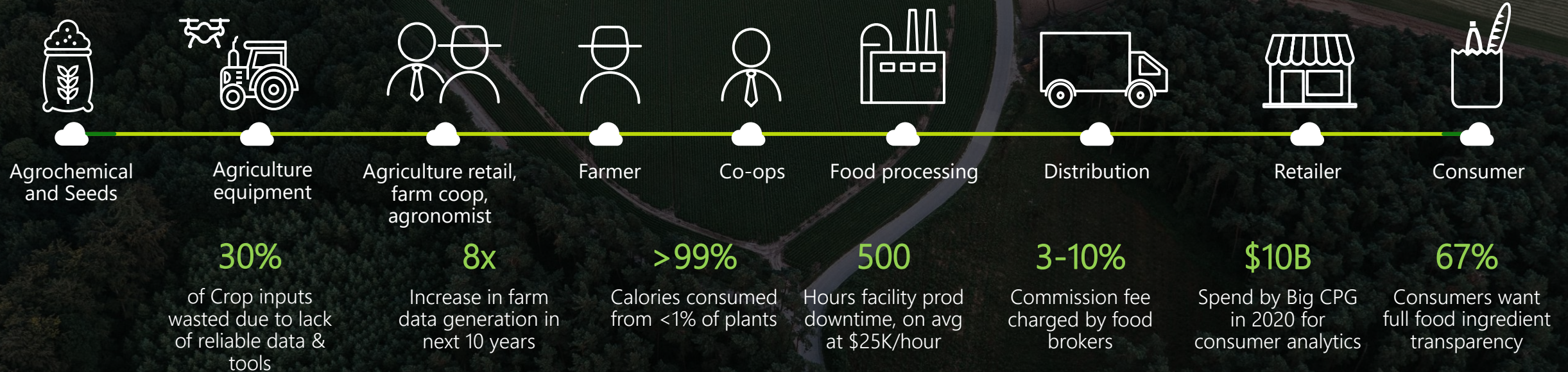
50% more food is needed by 2050.
40% food wasted.



31% GHG emissions from agri-food systems,
70% fresh water use

Data-driven Agri-Food systems

Bringing data to the cloud enables key insights for individuals and organizations.



When this data is shared, we unlock greater efficiencies and productivity across the supply chain.

Food Tech at Microsoft



Data-driven Agriculture
(ADMA (FarmBeats) + FarmVibes)



Food Supply Chain
Transparency (FoodVibes)



Healthy Food Production
(Modern R&D for Food)

Agriculture, food production, and climate change



18.4% of GHG emissions from Ag, Forestry, & Land Use



Food production accounts for **1/4th** of GHG emissions



Longer growing seasons in different parts of the world



Ag soils can sequester 20 PgC in 25 years, **10%** more than anthropogenic emissions

Data-driven agriculture

Precision & regenerative agriculture has been shown to:



Improve yield



Reduce cost



Ensure sustainability

According to USDA, **high cost of manual data collection** prevents farmers from using data-driven agriculture.

Exhibit 3

The high cost of agtech is a major barrier to adoption, followed by an unclear ROI.

High cost of technology

47%

of farmers cited as top-three barrier to adoption

Low willingness to pay

50%

of farmers are unwilling to pay anything

Unclear ROI

30%

of farmers cited as top-three barrier to adoption

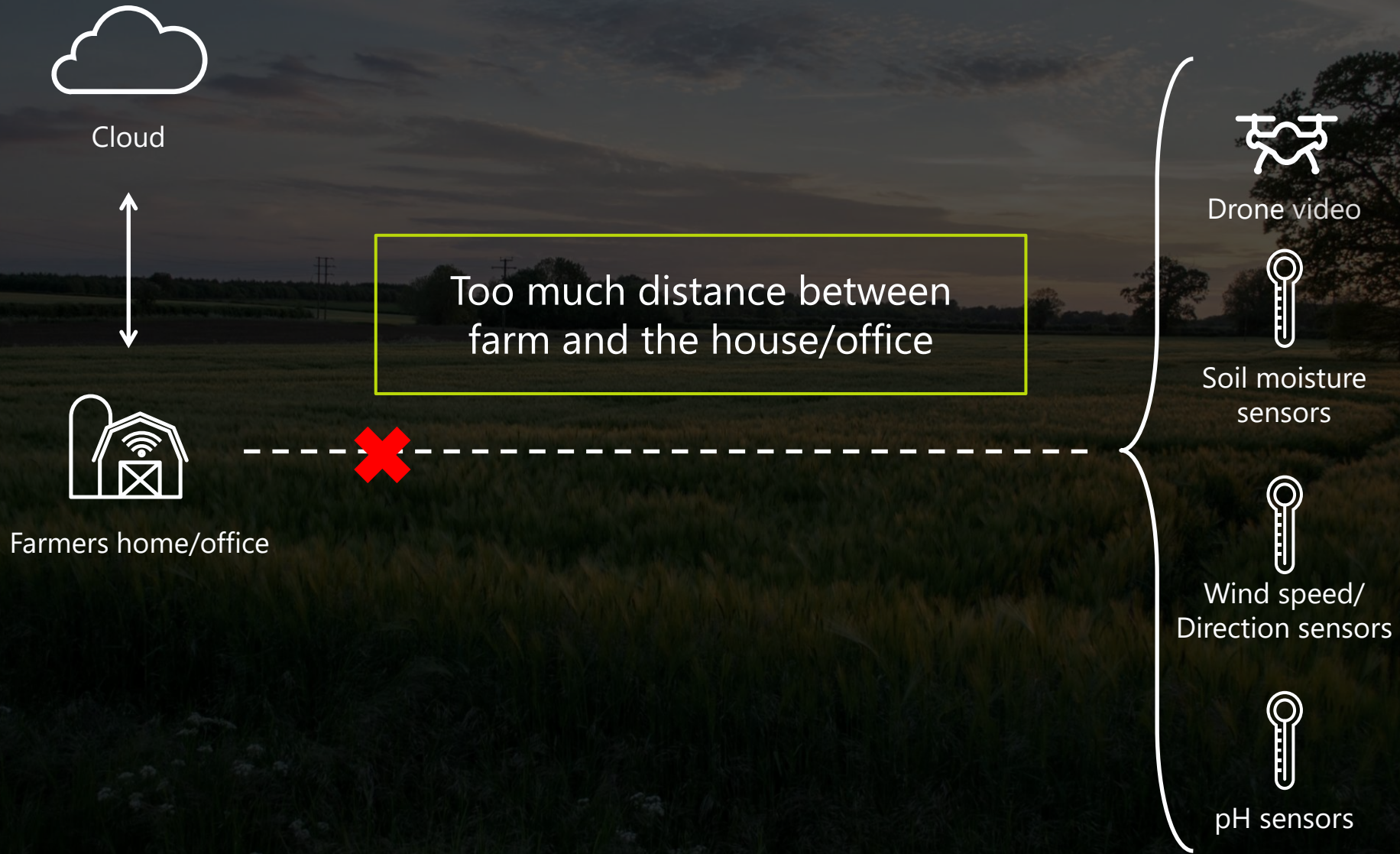
High ROI expectation

3:1

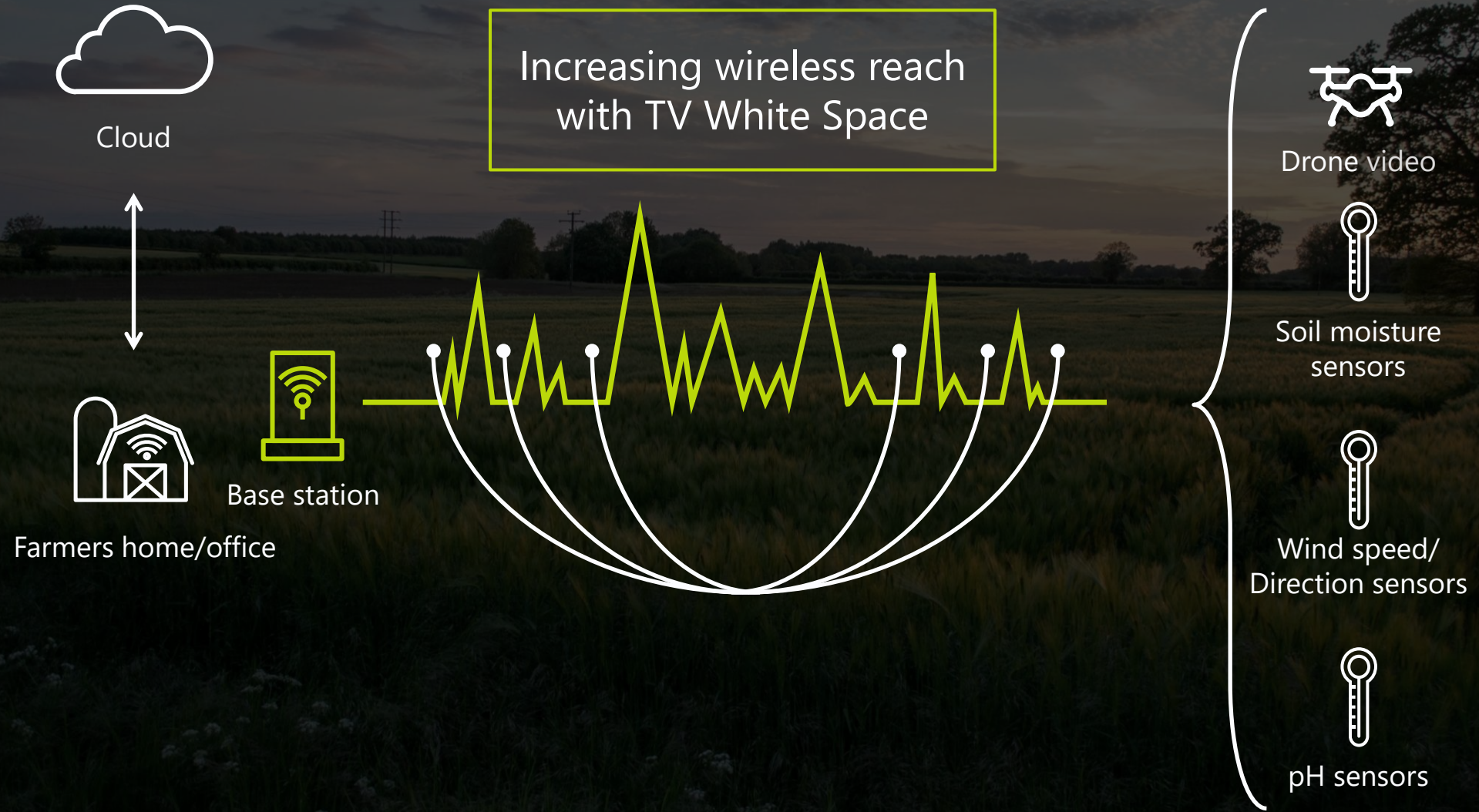
is the minimum-expected ROI to consider purchasing

Source: Farmers Global Insights Survey, McKinsey, May 2022; McKinsey analysis

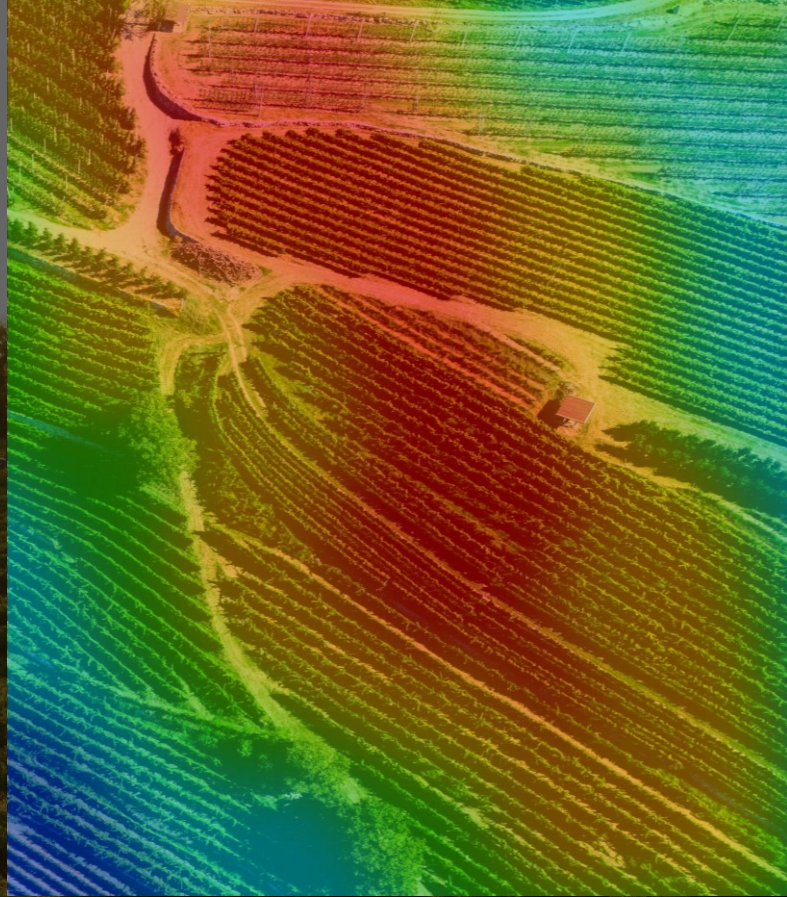
Challenge 1: Connectivity on farms



A solution in white space



Challenge 2: Sparse sensor deployments



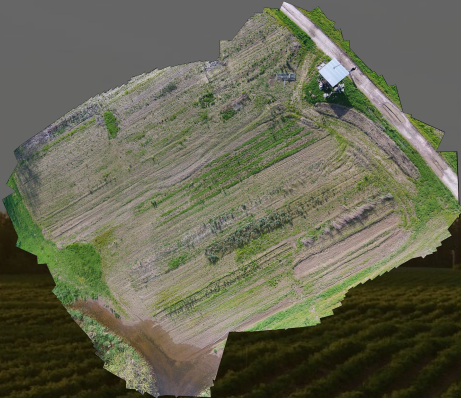
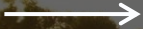
- Physical constraints due to farming practices
- Too expensive to deploy and maintain

How do we get coverage with a sparse sensor deployment?

Use aerial imagery and AI to enhance spatial coverage



Aerial imagery



Panoramic overview



Sensors



Machine Learning



Precision map

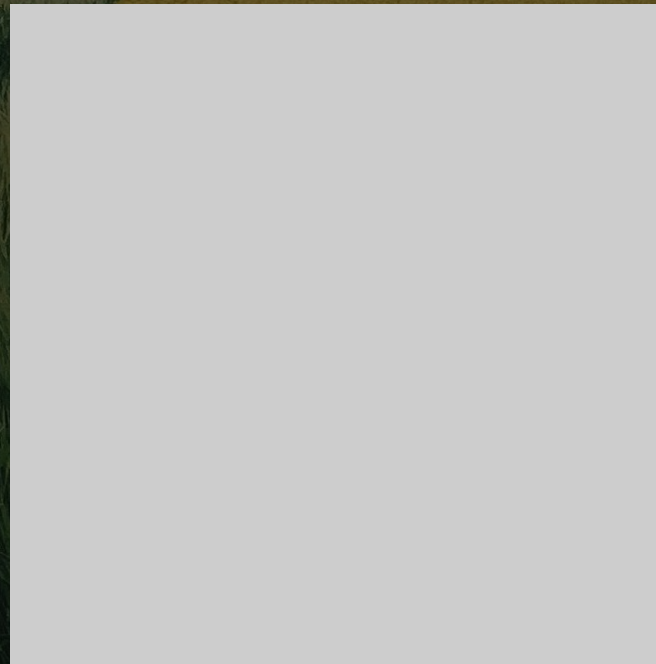
SpaceEye: Seeing through clouds over a farm

77% of the planet is covered in clouds.

Optical reconstruction machine learning fills the gaps created by cloud-cover

This allows for long term imaging and research without interruption.

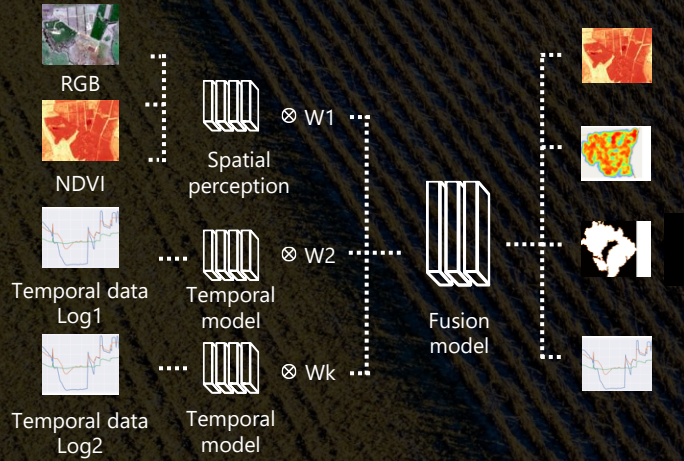
Original RGB bands



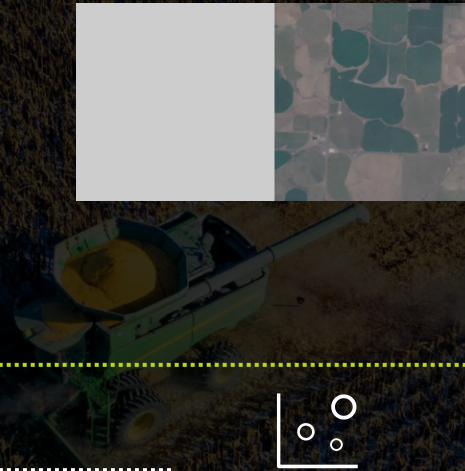
SpaceEye predicted RGB bands



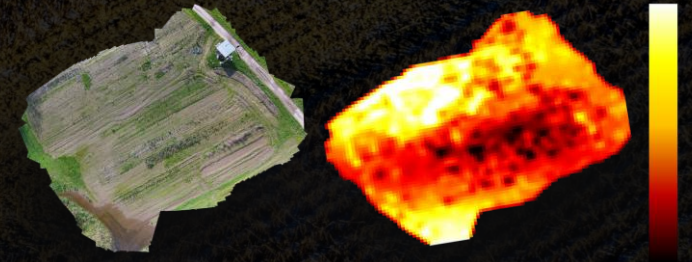
Spatio-temporal fusion



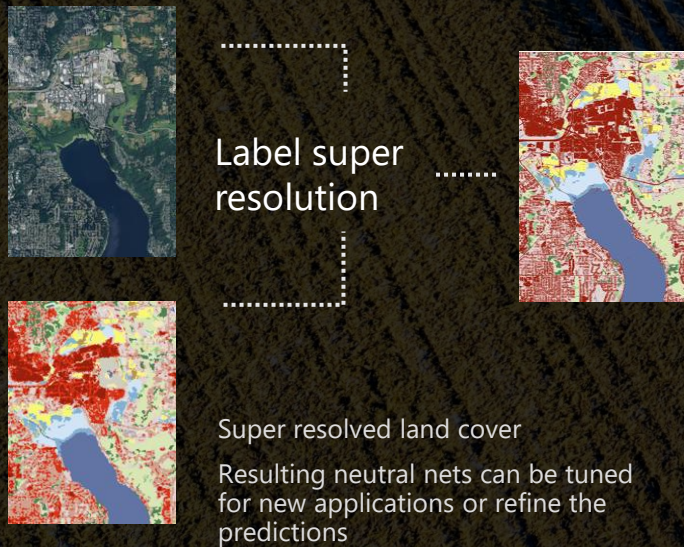
Project SpaceEye



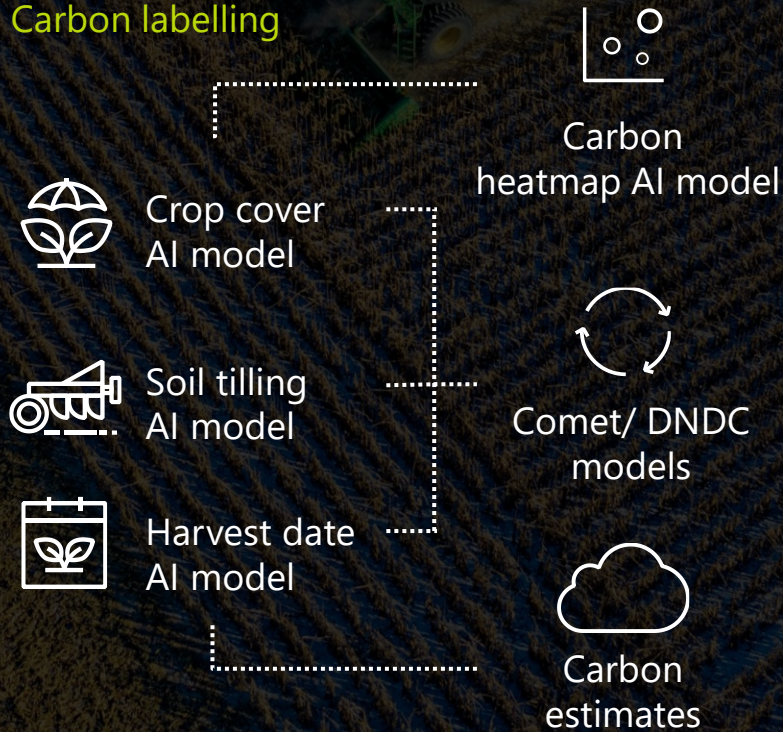
Moisture heat map








Landcover labelling



Carbon labelling



-  Yield maximization
-  Carbon minimization
-  Precision maps
-  Emission tracking
-  Practice verification

Trending: SOBA, a Twitch streamer community in Seattle, reboots vision and programming

Microsoft open-sources farm technologies, planting seeds for data-driven sustainable agriculture

BY TODD BISHOP on October 6, 2022 at 8:00 am

Microsoft is hoping its algorithms can help farmers—and the planet

You can't eat an algorithm, but data can still be useful when it comes to food production. Here's how.

BY HELEN BRADSHAW | PUBLISHED OCT 7, 2022 10:00 AM

 Microsoft
3d • 🌐

"Project FarmVibes is allowing us to build the farm of the future... it's saving a lot in costs and it's helping us control any issues we have on the farm," says fifth-generation farmer Andrew Nelson.

For Andrew, data is as important as dirt when it comes to agriculture. AI-powered technologies help reduce fertilizer use, forecast wind speeds, and identify soil moisture allowing farmers to reduce costs and boost yields.

Data-driven agriculture is not only important to the future of farming. In fact, it could be a solution to the global food shortage issue, helping increase food production while reducing the amount of natural resources agriculture demands.

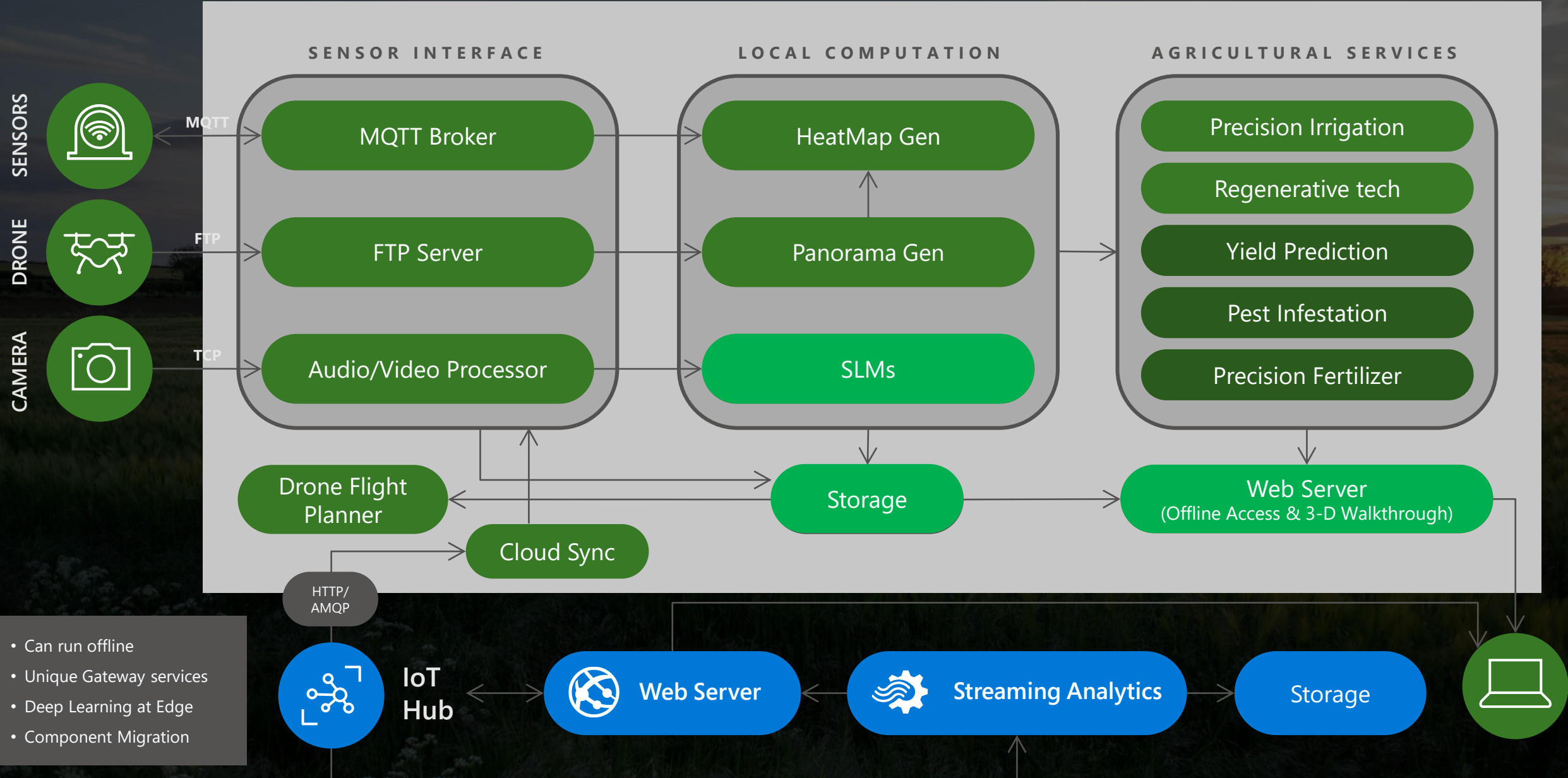
Get to know the farms of the future: <https://msft.it/6044dJRJE>



Challenge 3: Connectivity to the Cloud



Azure Edge



- Can run offline
- Unique Gateway services
- Deep Learning at Edge
- Component Migration

Deployment

Deployments in several locations including WA, CA, NY

Farm sizes range from 0.5 – 9000 acres

Sensors:

- DJI Drones
- FarmBeats sensor boxes with soil moisture, temperature, wind speed/direction sensors
- IP Cameras to capture IR imagery as well as monitoring

Cloud Components: Azure IoT Suite



Micro-Climate Forecasting

Goal:

Microclimate weather forecasting model based on FarmBeats sensors in the field.

Impact:

Knowing microclimate enables better modeling of plant diseases, application timing, and risk management.

Challenges:

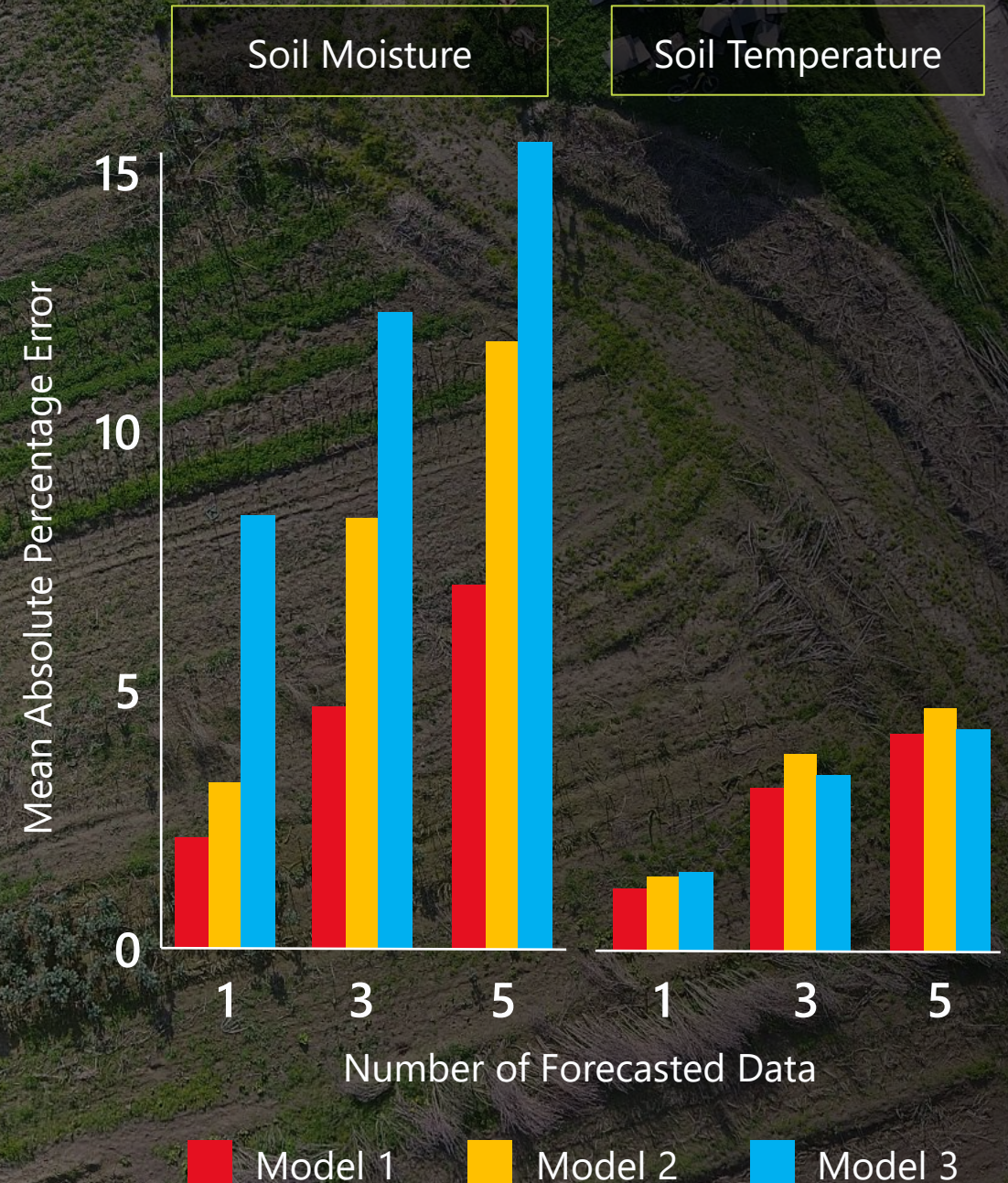
Forecast important variables for accurate plant disease prediction, not included in current weather forecasts (results shown).

Results:

Soil moisture & temperature forecasting error less than 10%.

Forecast for low temp was 42 degrees. Micro-Climate forecast was 31 degrees in lower areas of the field. Actual was 30 degrees. Instead of spraying grass herbicide, the farmer waited and avoided large crop damage in some of the most productive areas.

*The **lower the error**, the better the prediction.



Example: Panorama



Water puddle



Cow excreta



Cow herd

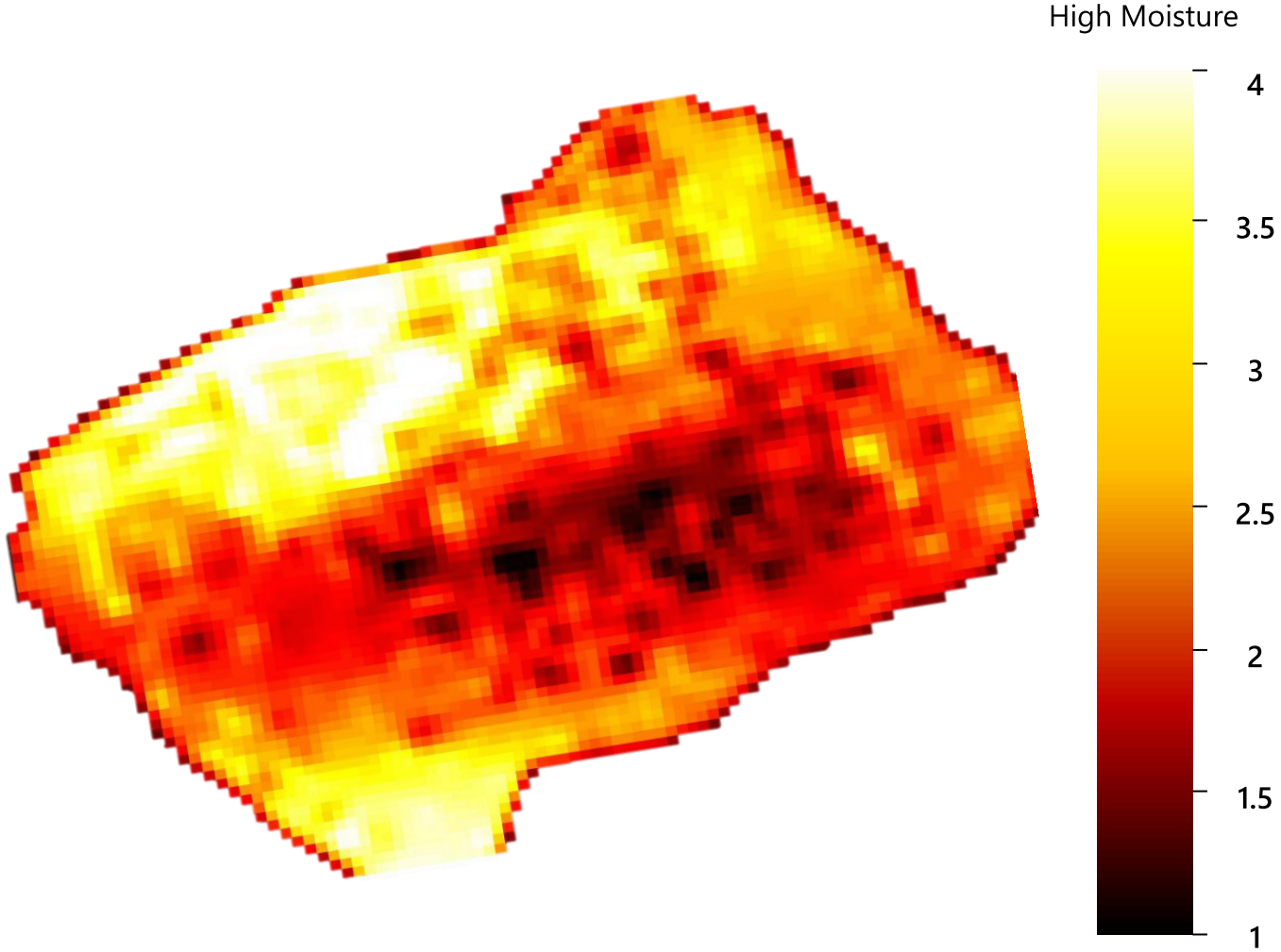


Stray cow

Precision Map: Panorama Generation



Precision Map: Moisture



High Moisture

4

3.5

3

2.5

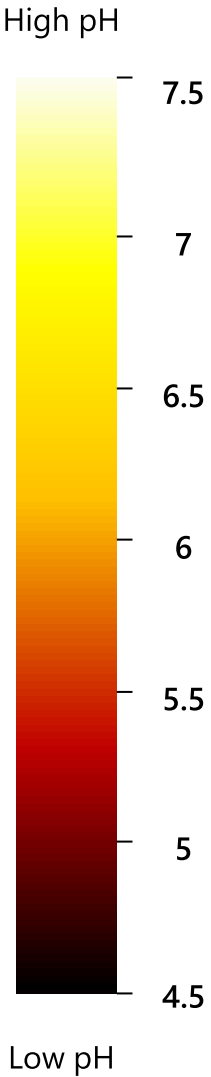
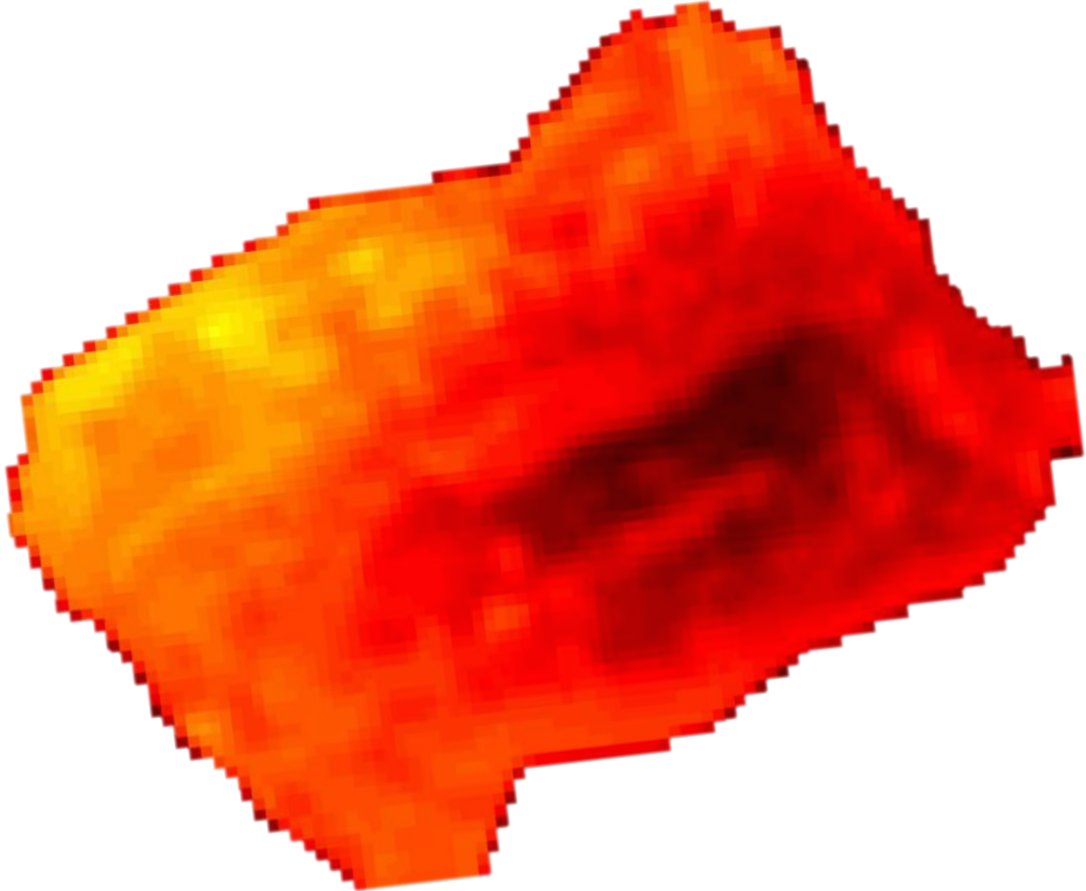
2

1.5

1

Low Moisture

Precision Map: pH



Application: Cow-shed monitor



Crop lifecycle

Pre-plant field preparation



Operations

- Eliminate weed and cover crop
- Plan and prepare for optimized carbon sequestration

Tech Used

- Carbon sequestration what-if analysis
 - FarmVibes.AI - CarbonWhatIf
- Li-Cor CO2 monitoring
- Multispectral drone flights
- Nutrient mapping
- Cloud free satellite imagery
 - FarmVibes.AI - SpaceEye
- Multispectral drone image processing
 - FarmVibes.Edge
- Variable rate glyphosate spraying

Planting



Operations

- Variable rate seeding, fertilizations, and depth seed planting

Tech Used

- Cloud free satellite imagery
 - FarmVibes.AI - SpaceEye
 - NVDI maps
- Soil testing locations
 - Innov8 sensor and/or crysalabs sensor
- Traditional lab tests
- Soil moisture sensor data collected
 - FarmVibes.Connect
- TVWS broadband/private LTE tractor connectivity
- Micro climate prediction
 - FarmVibes.AI - DeepMC
- Previous drone images
 - FarmVibes.Edge
- Drone application of cover crop seed

Post-planting/pre-emergence



Operations

- Apply variable rate for herbicides and target different weed herbicides

Tech Used

- Cloud free satellite imagery
 - FarmVibes.AI -SpaceEye
- Multispectral drone image processing
 - FarmVibes.Edge
- Weed detection AI from previous year's drone imagery
- Variable rate map for large sprayer
 - FarmVibes.AI
- Micro climate wind seed predictions
 - FarmVibes.AI - DeepMC

Crop lifecycle

Emerged crop



Operations

- Spray under recommended temperature and wind speed
- Apply variable rate herbicides and fertilization
- Monitor wildlife on fields
- Track in-season plant growth, health, and nutrients

Tech Used

- Cloud free satellite imagery
 - FarmVibes.AI - SpaceEye
- Nutrient mapping
 - Innov8, manual soil samples, chrysaLabs
- Temperature/wind speed prediction
 - FarmVibes.AI - DeepMC
- Multispectral drone image processing
 - FarmVibes.Edge
- Drone Image based AI maps
- AI camera-based Wildlife detection

Crop harvest



Operations

- Grain storage utilization
- Harvest tracking at truck level
- Measure truck weight at grain silos
- In field operational communication
- Harvest traceability at management zones level

Tech Used

- Tracking Pucks
- TVWS Broadband/Private LTE
- PowerBI
 - Grain bin utilization monitoring
- Custom application built in Azure(TicketTracker)
- Azure IoT Central

Post harvest



Operations

- Monitoring humidity, temperature, and CO2 for crop in grain silos
- Field Management Zone level tracking

Tech Used

- Tracking Pucks
- PowerBI
 - Grain bin environment monitoring
- Azure IoT Central

Impact to NelsonFarms

- Reduced precision pesticide and fertilizer application time
- Saved more than 38% of previously used on a chemical

Grain Storage Utilization

- Utilized 18% more grain storage
- Timing market for better price

Precision Seeding

- Optimized seeding for reduced waste



Future Farmers of America + FarmBeats + FarmVibes

The Microsoft TechSpark initiative is bringing precision agriculture and AI to the classroom with **FarmBeats student kits**.



Affordable sensing low-cost soil moisture and EC sensing using wi-fi

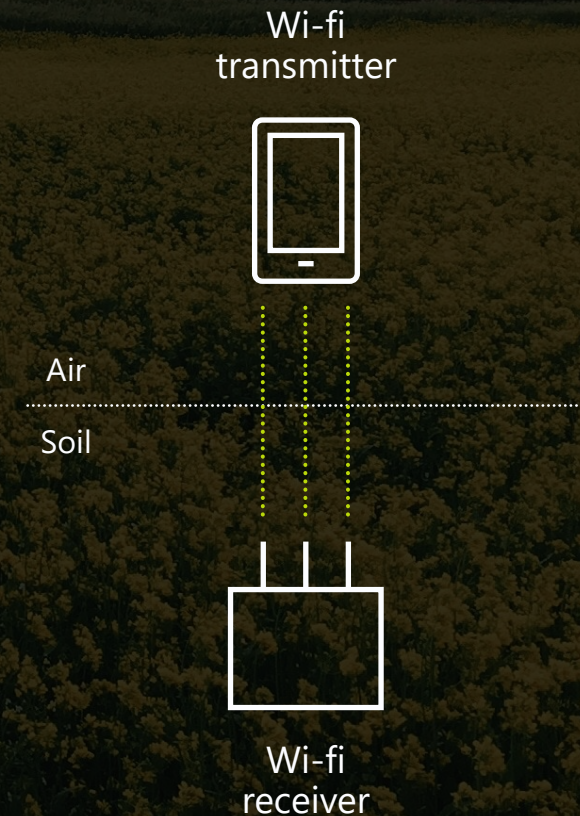
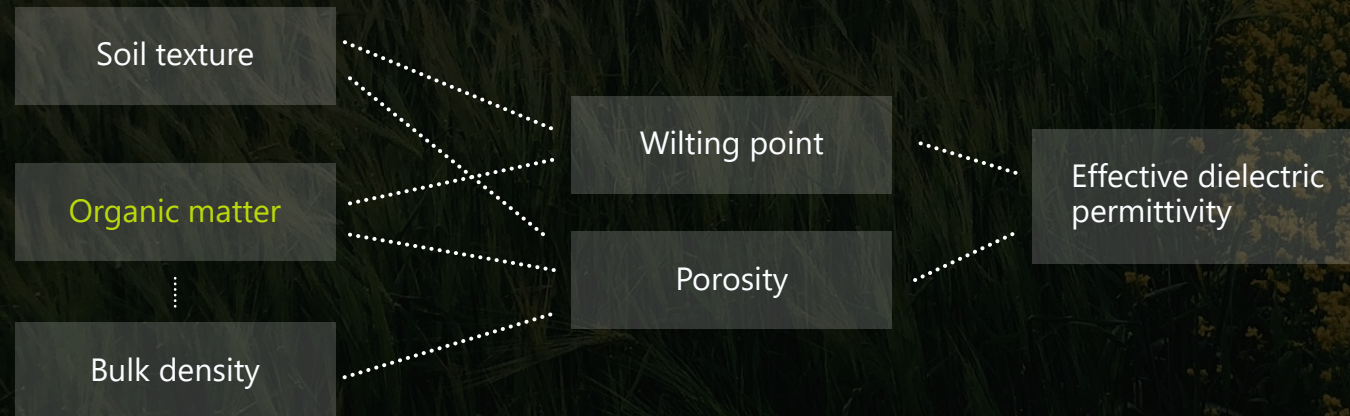
Motivation: existing sensors are expensive

- ~100s of dollars

Strobe design: Wi-Fi cards with 2+ antennas

- Relative time-of-flight and amplitude

Results: Strobe can accurately detect moisture and EC change in soil



Food Tech at Microsoft



Sustainable Agriculture
(FarmBeats + FarmVibes)



Food Supply Chain
Transparency (FoodVibes)



Healthy Food Production
(Modern R&D for Food)

The Food Supply Chain Challenge



50% more food needed by 2050.
40% food wasted.



2B+ lack vital nutrients.
500M+ suffer from foodborne illnesses.



31% GHG emissions from agri-food systems.
8% from food waste.



\$1.2T of food lost/wasted annually

COVID stretched the food supply chain:

- Food shelves were empty
- Food prices are up more than 20% over the last year
- Malnutrition increase by 15% in 2020
- Yet, even more food was wasted

Transparent Food Chains: Creating new opportunities for food

Traceability

Gain visibility across the food chain to improve safety



Track and trace



Food Safety & Recall

Nutrition

More accurate nutrition using info about ingredient sources, and supply chain conditions



Food Manufacturing



Alt Proteins

Sustainability

Provide farm & supply chain visibility to consumers, e.g. using regenerative ag

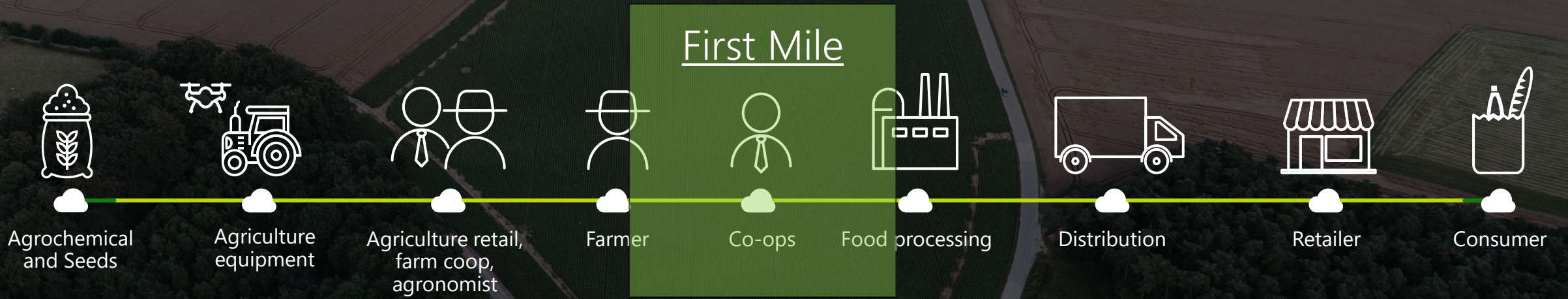


Food Waste



Sustainability labels

Key Challenge: The Opaque "First" Mile



From the farm gate to the first handoff: shipper/processor



50% food waste happens in 1st mile



6% GHG emissions by food waste in 1st mile



Salmonella, E. coli often start in 1st mile

4 challenges hindering digitization of the 1st mile...



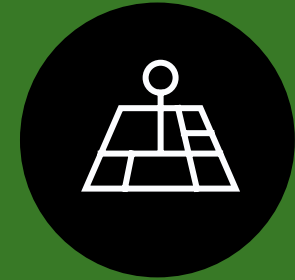
No connectivity
in 1st mile



Low digital
skills

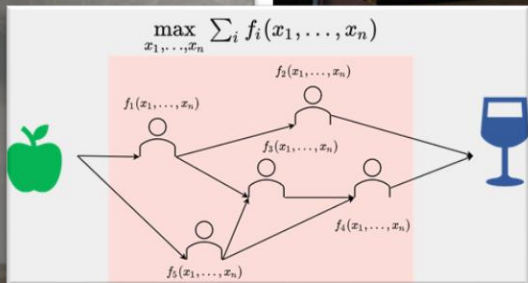


No visibility
in transport



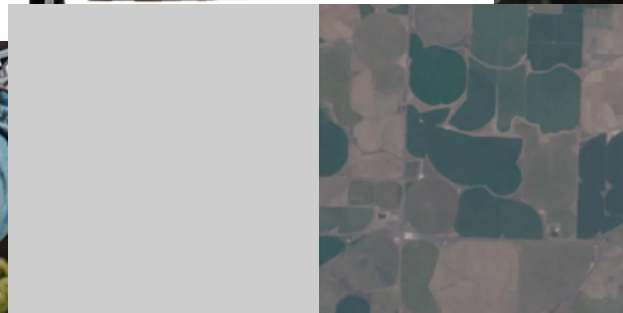
Sensing is
expensive

FoodVibes: **Hands-off, Low-Cost** Digitization of Food Supply Chain's 1st Mile



FoodVibes

A central graphic featuring a large green watermelon with a white drone flying above it. The text "FoodVibes" is written in white across the watermelon. Surrounding the watermelon are four green circular icons: a truck, a QR code, a bar chart with an 'x' above it, and a person icon.



Several companies have made commitments



Unilever's Knorr to launch 50 regenerative agriculture projects over five years

The CPG giant says it prioritizes "big, audacious goals" on sustainability over what it describes as incremental efforts by rivals.

Food Dive · 12d

Pepsi Launches Sustainable Agriculture Campaign for Climate Crisis

The recent climate summit has focused attention on global agriculture, which accounts for about 10 percent of the greenhouse gas emissions in the United States alone, and nearly 24 percent globally.

Research and Markets · 2d

Food Navigator

Danone talks regenerative agriculture: Linking dairy and plant

...

Danone talks regenerative agriculture: Linking dairy and plant-based at a farm level can yield sustainability gains ... Danone was an early...

Aug 27, 2021



The Food Beverage News

Nestlé's Plan to Shift to a Regenerative Food System – The

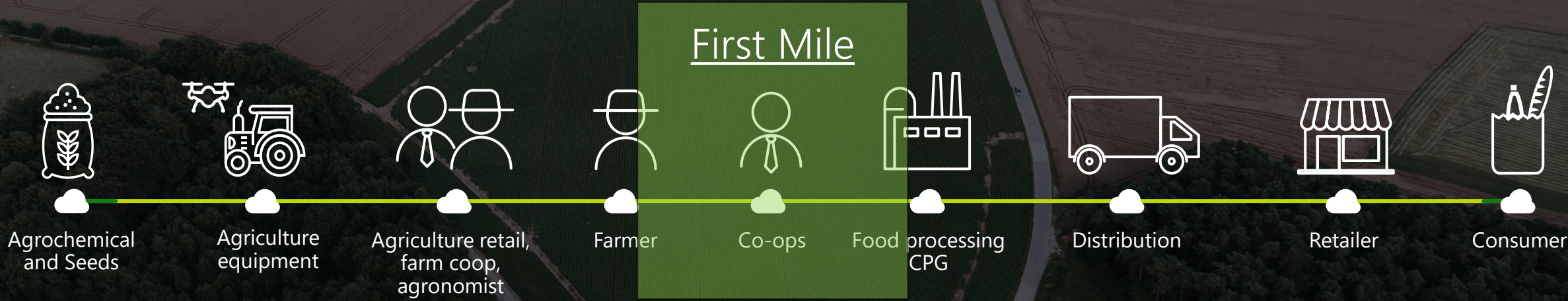
...

Nestle is investing around 1.7 billion over the period of 5 years to encourage regenerative agriculture across the supply chain of the...

1 day ago



Go-To-Market: The Partnership Ecosystem



- Partner with 1st mile providers
- CPG margins channeled upstream

FoodVibes Partner Ecosystem

CASE LEVEL IDENTIFICATION
 GTIN Global Trade Item Number and Extended Data
 Batch/Lot Number

(01) 2061414198765 2 (10) A1B2C3002

GDSN

PALLET LEVEL IDENTIFICATION
 SSCC Serial Shipping Container Code

(00) 00614141 000012345 2

ADVANCE SHIP NOTICE

- GTIN
- SSCC
- GLN

GS1 Extended Data: FOODVIBES 1st Mile

Sustainability Practices
 Harvest Date
 Storage Temp, Humidity

Sustainability service
 GHG emissions, water use, chemicals used

Nutrition service
 Time since harvest, nutrient content

Traceability service
 Food safety, Protocols followed, Diseases



Copilots in Agriculture



Farmer

Decision making for seeds, purchases, management



Agronomist

Communicate with farmer & advisories



Policy Maker

Make policy documents accessible to farmers



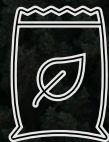
Banker

Communicate with farmers about loans, insurance



Supply Chain

Coordinate w/ farmers on prices, food standards



Ag Retailer

Help farmers with purchasing decisions



Ag/Data Scientist

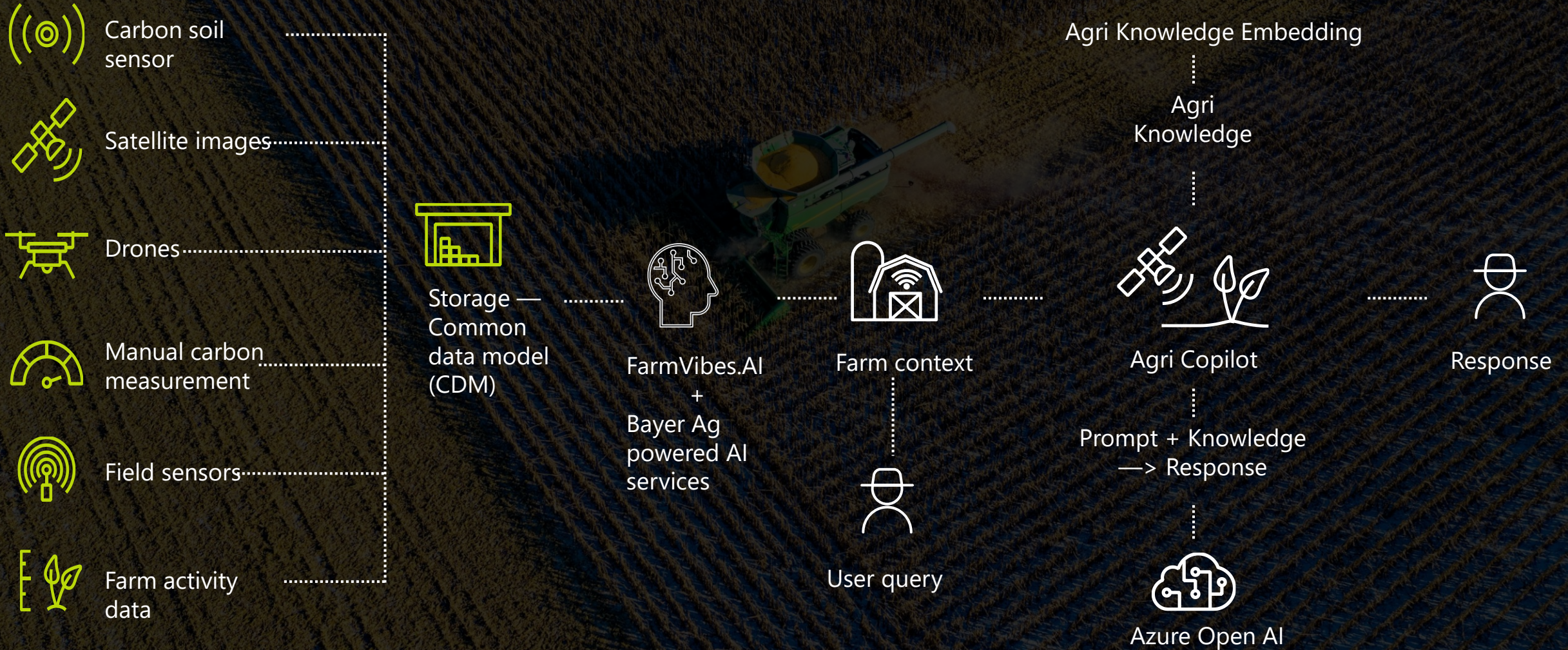
AI workflow automation



Food Manufacturing

Help farmers meet C standards

Agri CoPilot



Azure Data Manager for Agriculture

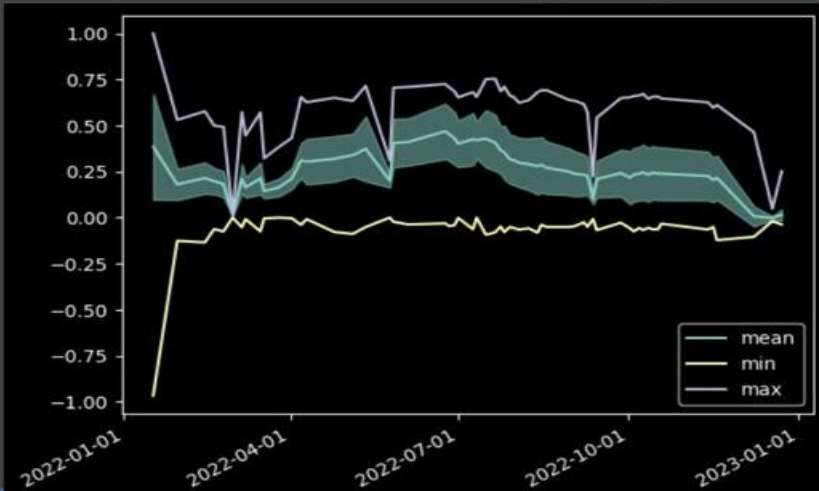
Agri CoPilot

You

Please analyze the summary of the health and vigor of my crops over the wheat growing season of 2022 in Farmington, WA.

Copilot

I have analyzed the health and vigor of your crops over the wheat growing season of 2022 in Farmington, WA. The NDVI summary provides information on the mean, standard deviation, maximum, and minimum NDVI values for the specified area and time range. You can access the results in CSV format by following this link: [NDVI](#)



[Summary CSV](#)

You

Yeah, but what the NDVI values you found for my crops mean? Anything I should pay attention to?

Copilot

Based on the NDVI values extracted from the CSV file, here's a summary of the crop health during the wheat growing season of 2022 in Farmington, WA:

- Mean NDVI values ranged from 0.00698 to 0.46860, indicating varying levels of vegetation health throughout the season.
- Minimum NDVI values ranged from -0.96667 to 0.0, with some negative values suggesting the presence of non-vegetated surfaces or stressed vegetation.
- Maximum NDVI values ranged from 0.22456 to 0.99955, with higher values indicating healthier and denser vegetation.

It's important to monitor the NDVI values throughout the growing season to identify any potential issues with crop health. If you notice a significant drop in NDVI values or consistently low values, it may be worth investigating further to determine the cause and take appropriate action to address any issues.

You

What products were applied to my Lowery field in the year 2023?

Copilot 0x12a9d14a

In 2023, the following products were applied to your Lowery field:

1. 32-0-0 UAN: 85.2 acres at an average rate of 1.0 gal/ac
2. Ally Extra: 85.2 acres at an average rate of 0.4 oz/ac
3. Liberate: 85.2 acres at an average rate of 2.4 oz/ac
4. MiCrop: 85.2 acres at an average rate of 10.0 oz/ac
5. Osprey Xtra: 18.8 acres at an average rate of 4.8 oz/ac
6. Power-Up: 85.2 acres at an average rate of 1.0 gal/ac
7. Truslate: 85.2 acres at an average rate of 24.0 oz/ac

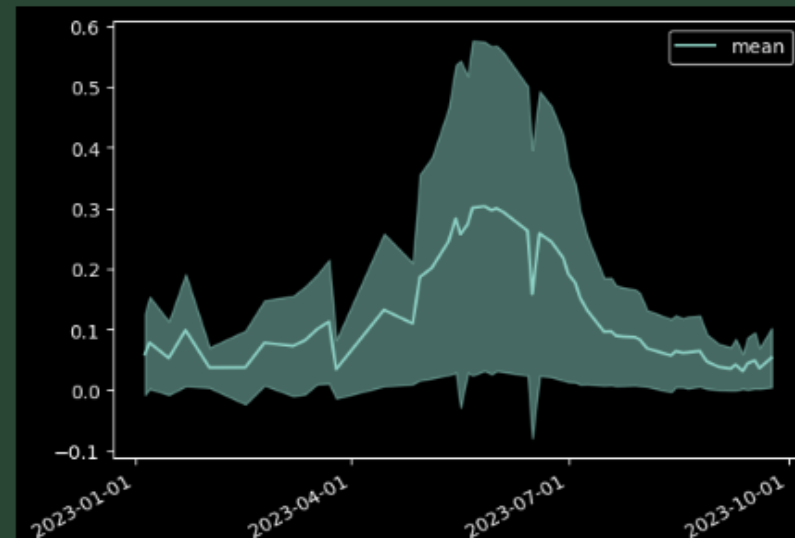
Please note that this information is based on the data available for your field.

You

How is the health of the crops since seeding?

Copilot 0x12a9d14a

Based on the NDVI data from 2023, the crop health in your Lowery field has shown fluctuations throughout the year. The NDVI values started relatively low in January, increased in May, and then gradually decreased until September. It's important to note that NDVI values can be influenced by various factors such as weather conditions, crop growth stages, and management practices. Overall, the crop health has experienced ups and downs, but without more context, it's difficult to determine the exact cause of these fluctuations. [Source of data](#)



Agri CoPilot

You

what is the best method of planting lettuce seeds?

Copilot 0x12a9d14a

The best method for planting lettuce seeds depends on the scale of your operation and the resources available. For small-scale gardens or home use, you can sow seeds directly into the soil or start them indoors in seed trays or pots. Space seeds about 1 inch apart and cover them with a thin layer of soil, about 1/8 to 1/4 inch deep. Keep the soil consistently moist and provide adequate light. For larger-scale operations, using a seed drill or precision seeder can help ensure even spacing and proper planting depth. Regardless of the method, it's important to thin seedlings to the appropriate spacing for the specific variety once they have developed their first true leaves.

You

what depth do we plant the lettuce seed for optimal germination?

Copilot 0x12a9d14a

For optimal germination, lettuce seeds should be planted at a shallow depth of about 1/8 to 1/4 inch. This allows the seeds to receive adequate light, which is essential for germination. Keep the soil consistently moist and provide a temperature range of 60-70°F (15-21°C) for the best germination results.

You

what soil temperature will my seeds germinate?

Copilot 0x12a9d14a

Lettuce seeds typically germinate best in soil temperatures between 60-70°F (15-21°C). However, they can still germinate at temperatures as low as 40°F (4°C) and as high as 80°F (27°C), although the germination rate may be slower outside the optimal range.

You

what is the ideal soil humidity for lettuce seed germination?

Copilot 0x12a9d14a

The ideal soil humidity for lettuce seed germination is consistently moist but not waterlogged. Aim for a soil moisture level of around 70-80% of field capacity. This ensures that the seeds have enough water to germinate without being overly saturated, which can lead to issues like damping-off or seed rot.

You

If you're currently on a 3-year rotation with fall wheat, spring wheat, and a legume on a 200-acre farm, how would you estimate your current budget based on this?

Copilot 0x12a9d14a

Here's a summary of the estimated budget for a 200-acre farm with a 3-year rotation of fall wheat, spring wheat, and a legume:

Initial Investments:

- Land Acquisition: \$3,000,000
- Soil Testing and Preparation: \$20,000
- Initial Crop Planting: \$40,000
- Initial Equipment Purchase: \$510,100
- Licenses and Permits: \$5,000

Recurring Expenses:

- Input Costs: \$45,000
- Labor Costs: \$140,000
- Maintenance: \$40,000
- Utilities: \$45,000
- Financing Costs: \$75,000
- Miscellaneous Costs: \$25,000

Revenue Streams:

- Crop Sales: \$450,000
- Government Subsidies and Grants: \$20,000
- Agritourism: \$10,000
- Crop Insurance Payouts: \$5,000

Profit Loss Metrics:

- Gross Revenue: \$480,000 per year
- Net Revenue: \$175,000 per year
- Operating Margins: 36.46%
- Breakeven Point: 17.14 years
- ROI: 4.89%

Funding and Capital:

- Personal Savings: \$500,000
- Bank Loans: \$1,000,000
- Government Grants: \$50,000
- Crowdfunding: \$25,000

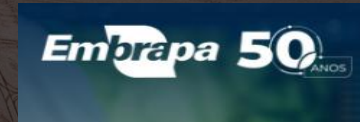
Please note that these estimates are based on available data and assumptions. Actual costs and revenues may vary depending on various factors such as location,

Can GPT-4 pass Agriculture Exams?



US Multiple Choice Questions

Model	Accuracy	+ RAG	+ Context	+RAG + Context
GPT 3.5	82%	82%	82%	88%
GPT 4	90%	90%	93%	93%



Brazil long form answers

Model	Accuracy	+ Context
GPT 3.5	59%	78%
GPT 4	72%	84%

Agri Exam

India Multiple Choice Questions

Model	Accuracy	+ RAG	+ Context	+RAG + Context
GPT 3.5	65%	69%	67%	68%
GPT 4	70%	78%	76%	79%
Human (#1 in the exam)	78%			

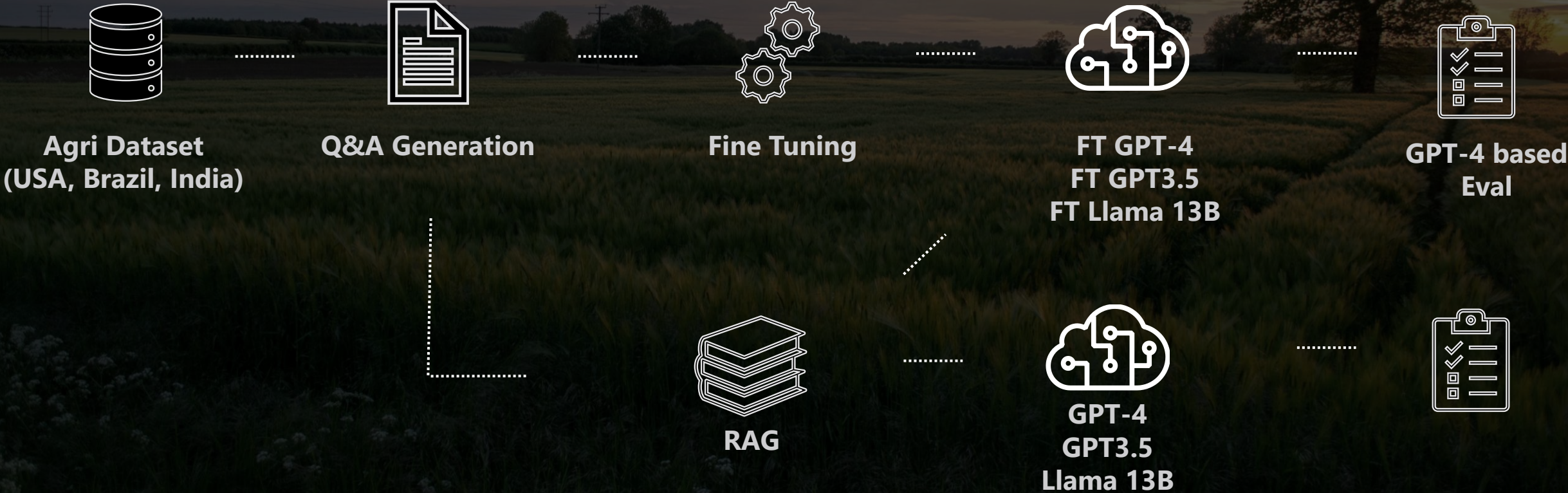
GPT also makes mistakes...

Who is the advocate of the "Marthandam" Rural Development Programme?

- a) Spencer Hatch
- b) Daniel Hamiltion
- c) A.T. Mosher
- d) M.K. Gandhi

Ref Answer: a) Spencer Hatch
GPT Answer: b) M.K. Gandhi

Fine Tuning vs RAG vs FT+RAG



Insights on RAG vs FT vs FT + RAG

RAG improves accuracy for large models

- * RAG on fine-tuned model gives best results
- * integration with satellite + farm context lights up new scenarios

Fine-tuning might help learn new knowledge

- * early results show promise

	RAG	Fine Tuning
Cost – Input token size	Increased Prompt Size	Minimal
Cost – output token size	More verbose, harder to steer	Precise, tuned for brevity
Initial cost	Low – creating embeddings	High – fine tuning
Accuracy	Effective	Effective
New Knowledge	If data is in context	New skill in domain

I am a cotton farmer in India, and found a worm on the flower. What is it?

Without a clearer image, it is difficult to accurately identify the worm. However, based on its location on the flower and its appearance, it could be a caterpillar of the cotton bollworm (*Helicoverpa armigera*). This pest is known to feed on cotton flowers and can cause damage to the crop.



I am a chili farmer in India, and I am seeing this disease in the image below. What is it?

This appears to be root-knot nematode damage. Root-knot nematodes are microscopic roundworms that infect the roots of plants, causing them to form galls or knots. This reduces the plant's ability to take up water and nutrients, leading to stunted growth and reduced yield. The presence of the galls on the roots is a characteristic symptom of root-knot nematode infection. Other symptoms may include yellowing and wilting of the leaves, and reduced fruit size and quality. Control measures for root-knot nematodes include crop rotation, soil solarization, and the use of nematicides. It is also important to practice good sanitation and hygiene in the field to prevent the spread of the nematodes.

Are you sure it is not root rot? (this was originally the agronomist's recommendation)

I have seen similar symptoms in chilli plants affected by root rot. It is possible that root rot could also be present, as root-knot nematode damage can make plants more susceptible to other soil-borne diseases. However, the presence of the galls on the roots is a characteristic symptom of root-knot nematode infection, which is why I believe that is the primary issue here.



Testimonial:

This was very cool. The agronomist first said, root rot. GPT-4 said root nematode. I called other experts to confirm that it was indeed root nematode!

I am a farmer
has been
causing it

This is another picture:



The small
include:

- Flea beetle
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To deter

what should i do to control bacterial leaf spot on my chili plants in karnataka

- ✓ Searching for: **bacterial leaf spot chili plants karnataka**
- ✓ Generating answers for you...



Your personal and company data are protected in this chat

According to an article from The Hindu ¹, bacterial leaf spot in chili plants can be controlled by spraying Agrimycin 100 alone or with 3gm/l copper oxychloride/ copper sulphate or 2gm/l mancozeb. Infection takes place under a wide range of temperatures with peak infection during July-September. The bacterium spreads within the field by wind driven rain droplets, clipping of transplants and aerosols. I hope this helps!

Learn more: [1. thehindu.com](https://www.thehindu.com) [2. bing.com](https://www.bing.com) [3. kssdb.karnataka.gov.in](https://www.kssdb.karnataka.gov.in) +5 more

s of water
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label

LLMs + Reasoning

An agricultural retailer has 3 warehouses and serves 5 farming regions. Each warehouse has a limited stock of three types of fertilizers: Nitrogen (N), Phosphorus (P), and Potassium (K). The demand for each fertilizer type in each region is known, and the transportation cost per ton of fertilizer from each warehouse to each region is also provided.

Details:

Warehouse Capacities (in tons):

Warehouse A: 300 tons of N, 200 tons of P, 100 tons of K

Warehouse B: 400 tons of N, 300 tons of P, 200 tons of K

Warehouse C: 500 tons of N, 400 tons of P, 300 tons of K

Region Demand (in tons):

Region 1: 150 tons of N, 100 tons of P, 80 tons of K

Region 2: 200 tons of N, 150 tons of P, 100 tons of K

Region 3: 100 tons of N, 120 tons of P, 60 tons of K

Region 4: 250 tons of N, 180 tons of P, 150 tons of K

Region 5: 200 tons of N, 150 tons of P, 120 tons of K

Transportation Cost (in \$ per ton):

Warehouse A to Regions 1-5: \$50, \$70, \$60, \$80, \$90

Warehouse B to Regions 1-5: \$60, \$50, \$70, \$90, \$80

Warehouse C to Regions 1-5: \$70, \$60, \$80, \$90, \$50

Problem:

Determine the optimal allocation of fertilizers from the warehouses to the regions to minimize the total transportation cost while meeting the demands of all regions and not exceeding the stock capacities of the warehouses.

Constraints:

Each warehouse's fertilizer stock cannot be exceeded.

Each region's fertilizer demand must be fully met.

Transportation is limited to available routes and their respective costs.

Thought for 1m 30s ^

Formulating variables and objectives

I'm setting up variables for the allocation of fertilizer P, balancing supply and demand at regions.

Aligning resources

Ensuring supply at warehouses and distribution paths, while keeping non-negative flows.

Analyzing costs

Mapping out transportation cost type and distance. This helps determine the most efficient routes.

Mapping linear programming

I'm working out a linear programming model with warehouses, demand constraints, and minimizing total cost.

Breaking down the problem

I'm thinking of simplifying this large problem into smaller, more manageable parts separately. The consistent unit transport cost is a key factor.

Isolating the issue

I'm simplifying things by tackling specific demands. This approach trims down the complexity.

Allocating supplies

Ensuring the total supply of 900 tons to meet demand, revealing a partial surplus at W_C.

Balancing supplies

I'm allocating supplies to different regions, ensuring no unfound surplus for better distribution.

Assessing transportation options

I'm exploring cost-saving measures from W_B and W_C to R4, revealing a more efficient path.

Re-evaluating paths

I'm looking at reallocating W_B and W_C, ensuring consistency, meaning no clear cost advantage.

Mapping out supply routes

I'm analyzing the allocation of W_C, ensuring consistency, making any cost-saving measures.

Evaluating cost shifts

I'm noting that reallocating W_B and W_C, compared to the original \$28,000, reveals a more efficient solution.

Finding the best route

I'm assessing the initial allocations, making me think about optimizing the distribution.

Adjusting allocations

I'm finalizing the reallocation of W_C, ensuring efficiency. The total cost is now \$43,600.

Wrapping up allocations

I'm finalizing the distributions to meet demand and minimize waste. However, R2's demand of 200 units remains unmet, highlighting a need for further adjustment.

Optimizing allocations

I'm tweaking the allocation of W_C to R2, but the new distribution is costing \$64,000, which is more than the previous \$55,500. This suggests more adjustments are needed.

Evaluating alternatives

Taking a closer look, it seems the initial solution is likely the most cost-effective. This conclusion comes from comparing the total costs incurred, confirming there's no need for further tweaks.

Allocating supplies

OK, let me see. I'm thinking about distributing fertilizer P from warehouses to regions, matching the initial solution's cost. Total supply surpasses demand, ensuring all needs are efficiently met.

Assessing options

I'm looking at reallocating W_B to R5 at \$80 per ton or W_C to R4 at \$90 per ton, but both paths are equally costly.

Piecing together costs

I've identified the supply and demand, ensuring all needs are met. The total cost for distributing fertilizer P is \$43,600, with no potential for further savings at this time.

Reallocating supplies

I'm thinking through shifting W_C's surplus to R4, adjusting all supplies and demands. This fine-tunes the distribution, revealing potential ways to enhance efficiency and cost-effectiveness.

Reallocating for efficiency

I'm shifting W_B's 110 units to R3 at \$70 per ton. With all demands now met, the leftover W_B is 10 units.

Conclusion

By allocating fertilizers according to the above plan, we minimize the total transportation cost to **\$131,600** while meeting all regional demands and not exceeding warehouse capacities.

Answer:

An optimal allocation that minimizes total transportation cost while meeting all demands is:

Nitrogen (N):

- Warehouse A sends 150 t to Region 1 at \$50/t and 100 t to Region 3 at \$60/t.
- Warehouse B sends 200 t to Region 2 at \$50/t and 200 t to Region 4 at \$90/t.
- Warehouse C sends 200 t to Region 5 at \$50/t.

Phosphorus (P):

- Warehouse A sends 100 t to Region 1 at \$50/t and 100 t to Region 3 at \$60/t.
- Warehouse B sends 150 t to Region 2 at \$50/t, 20 t to Region 3 at \$70/t, and 130 t to Region 4 at \$90/t.
- Warehouse C sends 150 t to Region 5 at \$50/t and 50 t to Region 4 at \$90/t.

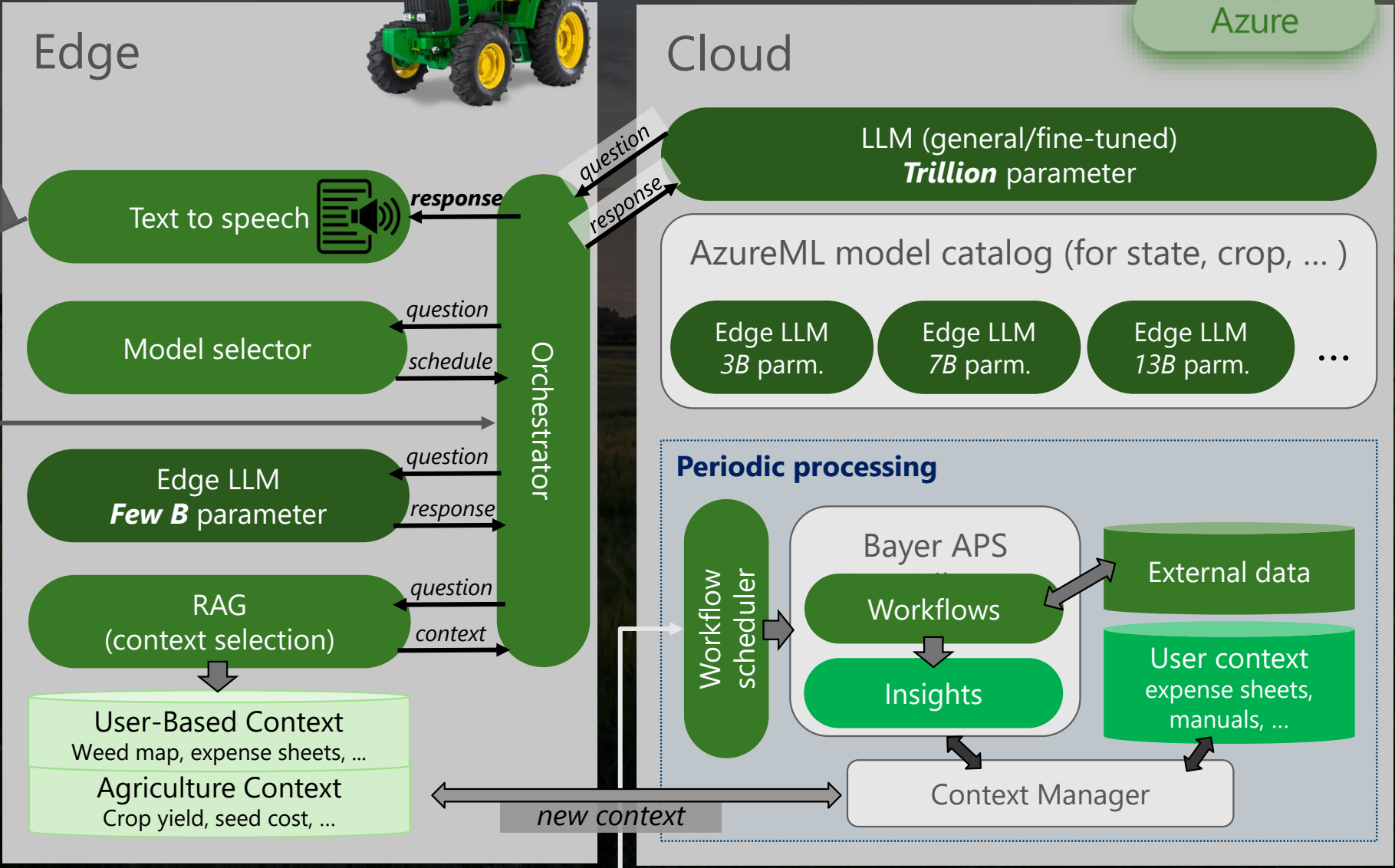
Potassium (K):

- Warehouse A sends 80 t to Region 1 at \$50/t and 20 t to Region 3 at \$60/t.
- Warehouse B sends 100 t to Region 2 at \$50/t, 40 t to Region 3 at \$70/t, and 60 t to Region 4 at \$90/t.
- Warehouse C sends 120 t to Region 5 at \$50/t and 90 t to Region 4 at \$90/t.

This plan minimizes total transportation cost to **\$131,600** while satisfying all constraints.

Tractor Co-Pilot

question:
What are the dark black spots on my corn leaves?



raw data





Microsoft

@ranveerchandra