Data-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.

Agrochemical and Seeds	Agriculture equipment	Agriculture retail, farm coop, agronomist	Farmer	Co-ops	Food processing	Distribution	Retailer	Consumer
	30% of Crop inputs wasted due to lack of reliable data & tools	8x Increase in farm data generation in next 10 years	>99% Calories consumed from <1% of plants		500 Hours facility prod downtime, on avg at $25K/hour	3-10% Commission fee charged by food brokers	$10B Spend by Big CPG in 2020 for consumer analytics	67% Consumers want full food ingredient transparency

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

Food Research at MSR

Sustainable Agriculture
(TerraVibes)

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 **¼th** 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

FarmVibes: Our Goal

Generate soil maps & sustainability insights at
two orders of magnitude lower cost
than existing approaches.

FarmVibes

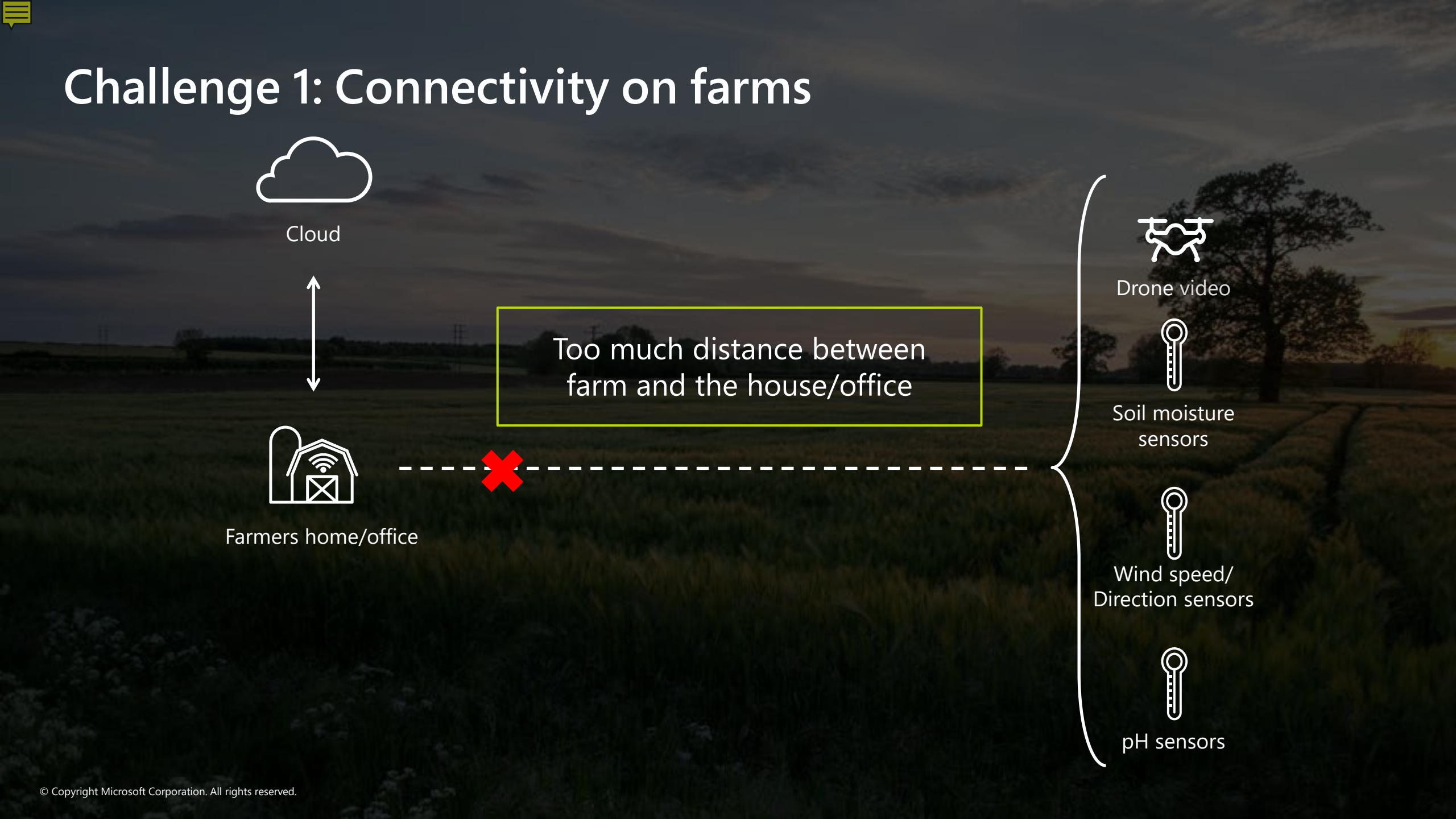
Soil Maps & Farm Insights to help farmers

Reduce emissions

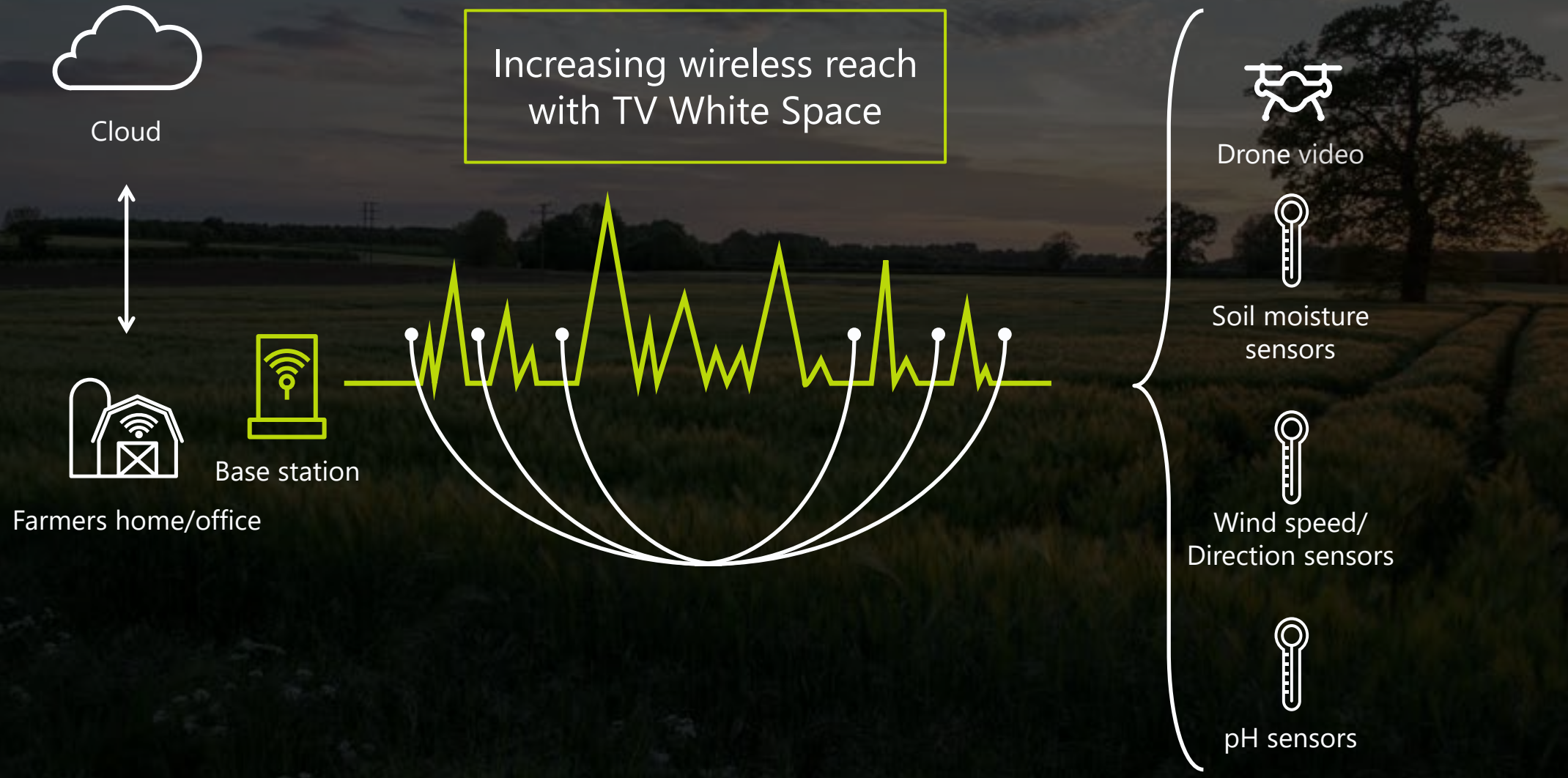
Climate Adaptation

Sequester Carbon

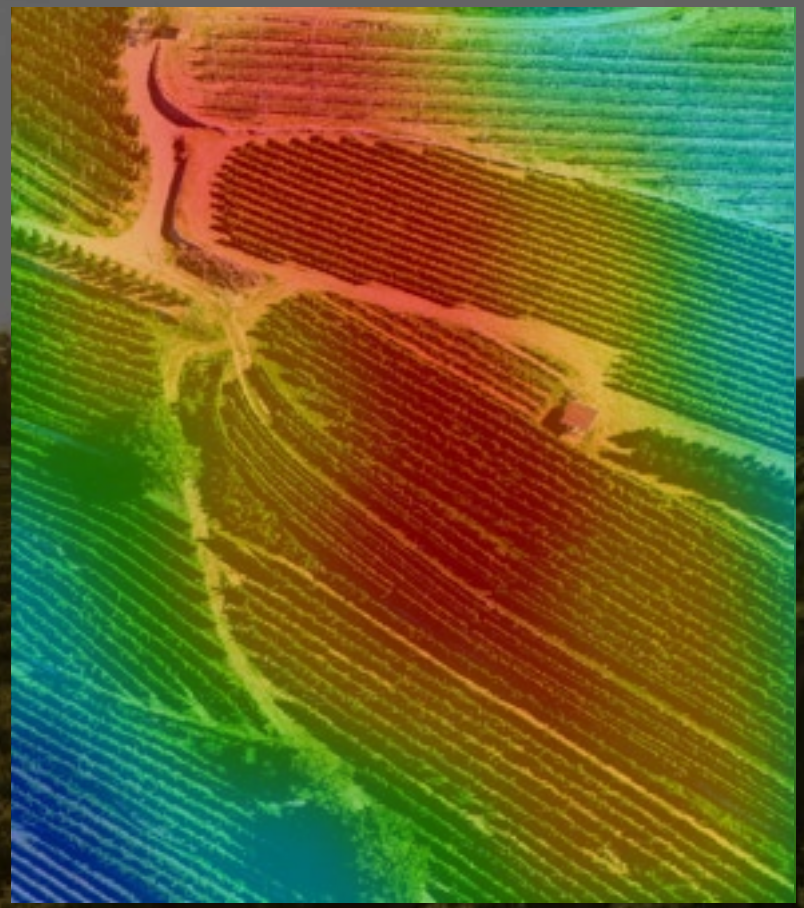
Challenge 1: Connectivity on farms



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

SpaceEye: Seeing through clouds over a farm

77% of the planet is covered in clouds.

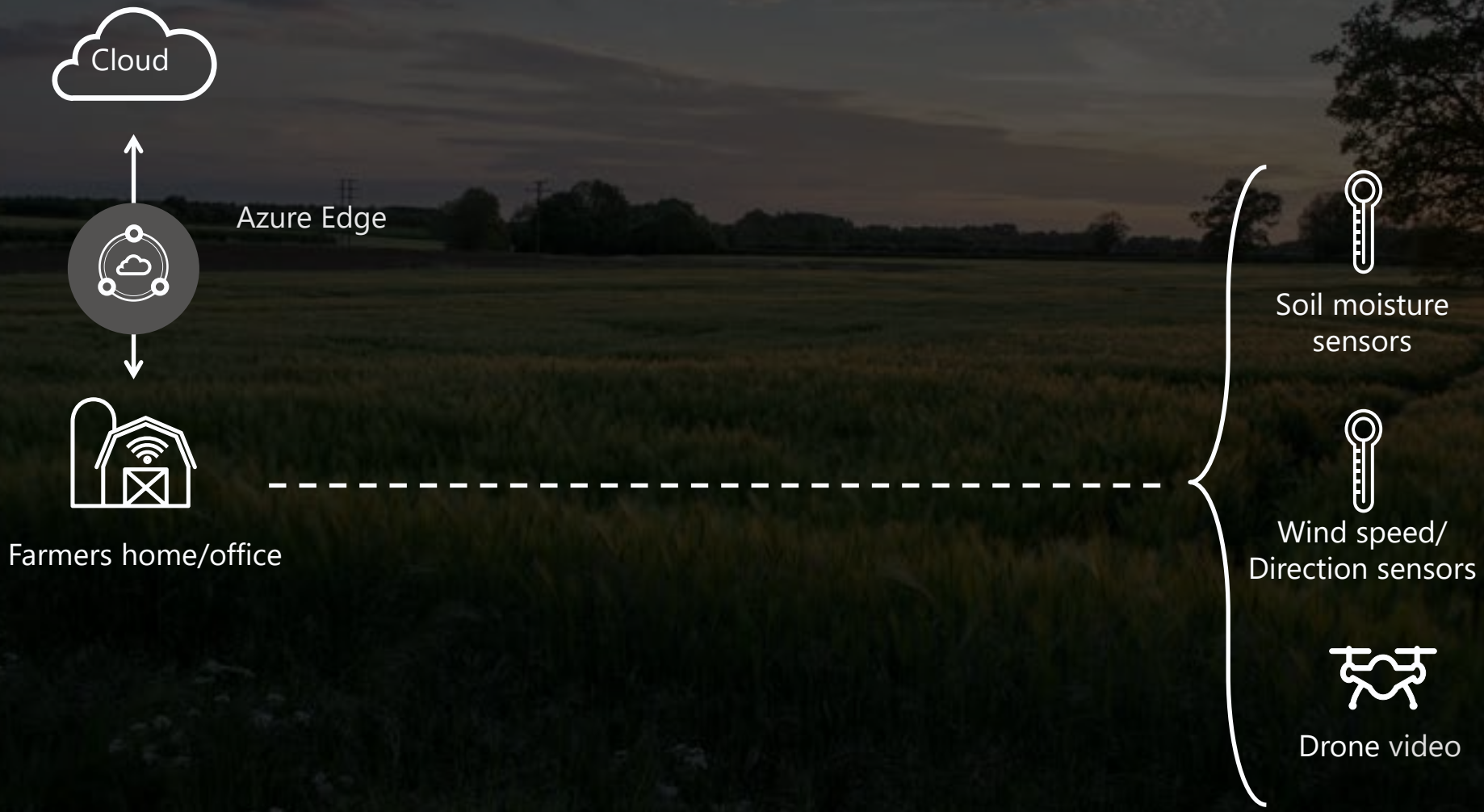
Optical reconstruction machine learning fills the gaps created by cloud-cover

This allows for long term imaging and research without interruption.

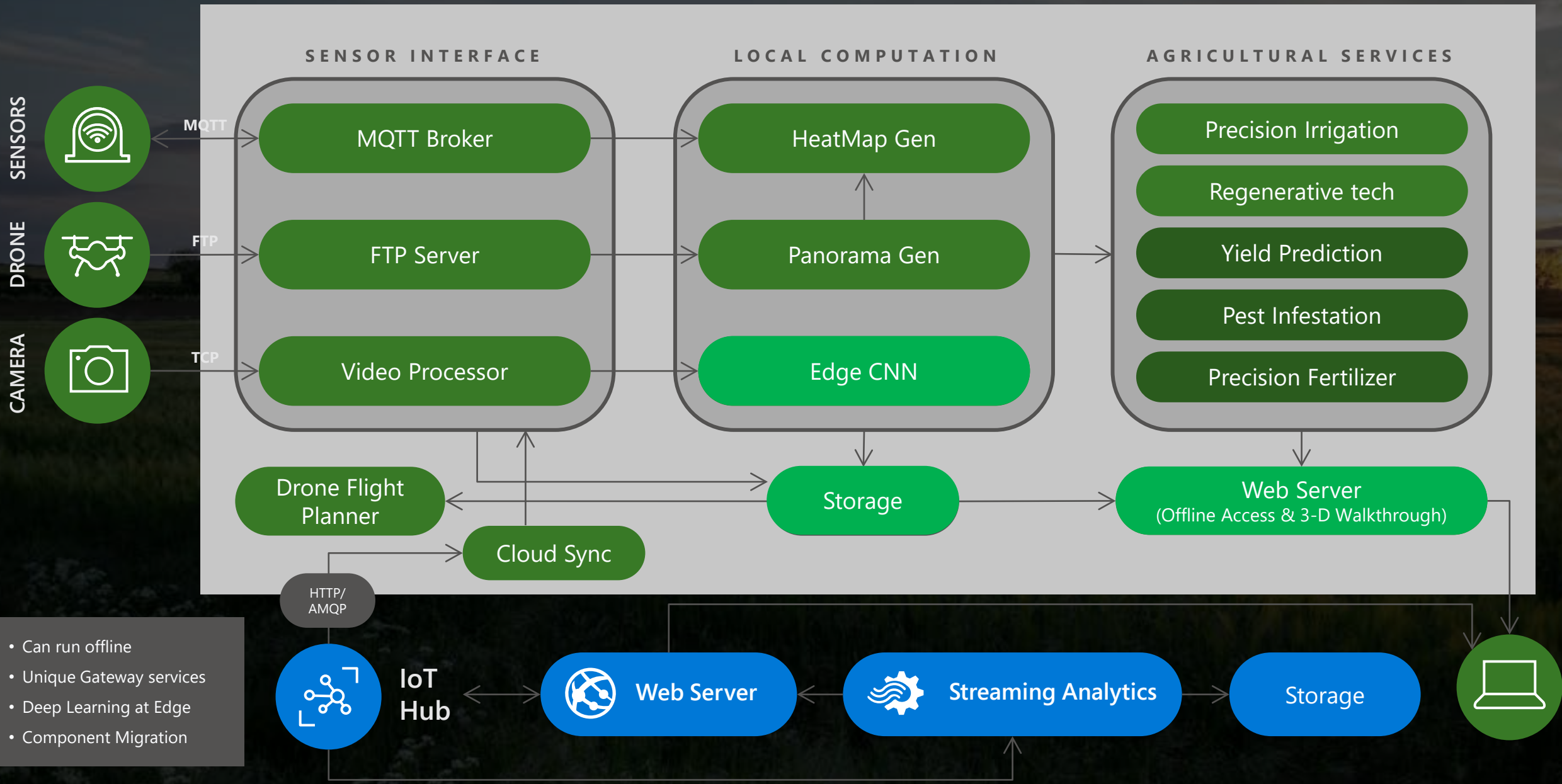
Original RGB bands

SpaceEye predicted RGB bands

Challenge 3: Connectivity to the Cloud



Azure Edge



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

Challenge 4: Tech Savviness of Farmers & Agronomists


Carbon soil sensor


Satellite images


Drones


Manual carbon measurement


Field sensors


Farm activity data


Storage — Common data model (CDM)


Farm context


Azure cognitive search

Query
—> Response


Agri GPT


User query

Prompt + Knowledge
—> Response


Azure Open AI GPT/Chat GPT

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.

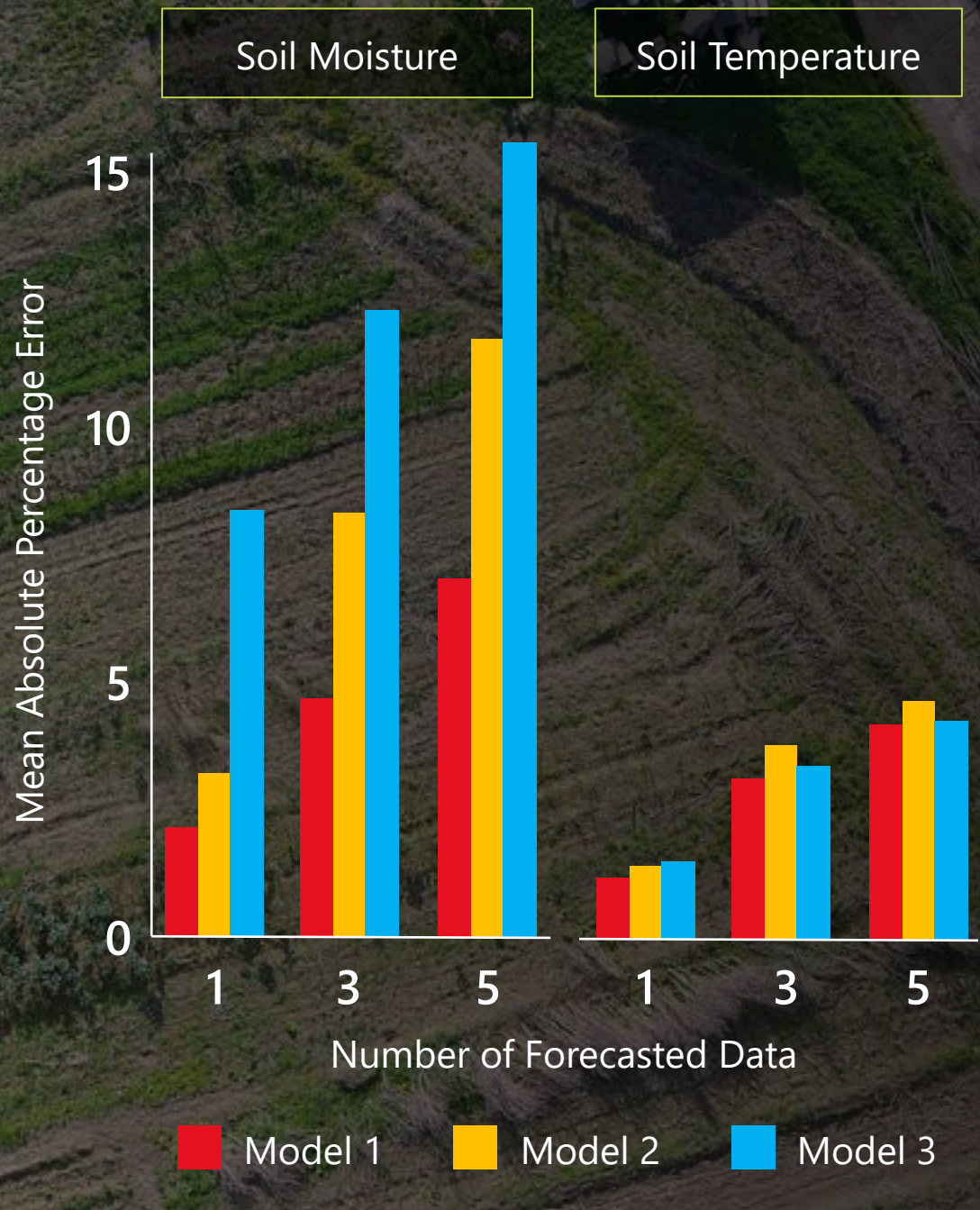
Impact:
Knowing microclimate enables better modeling of plant diseases, application timing, and risk management.

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

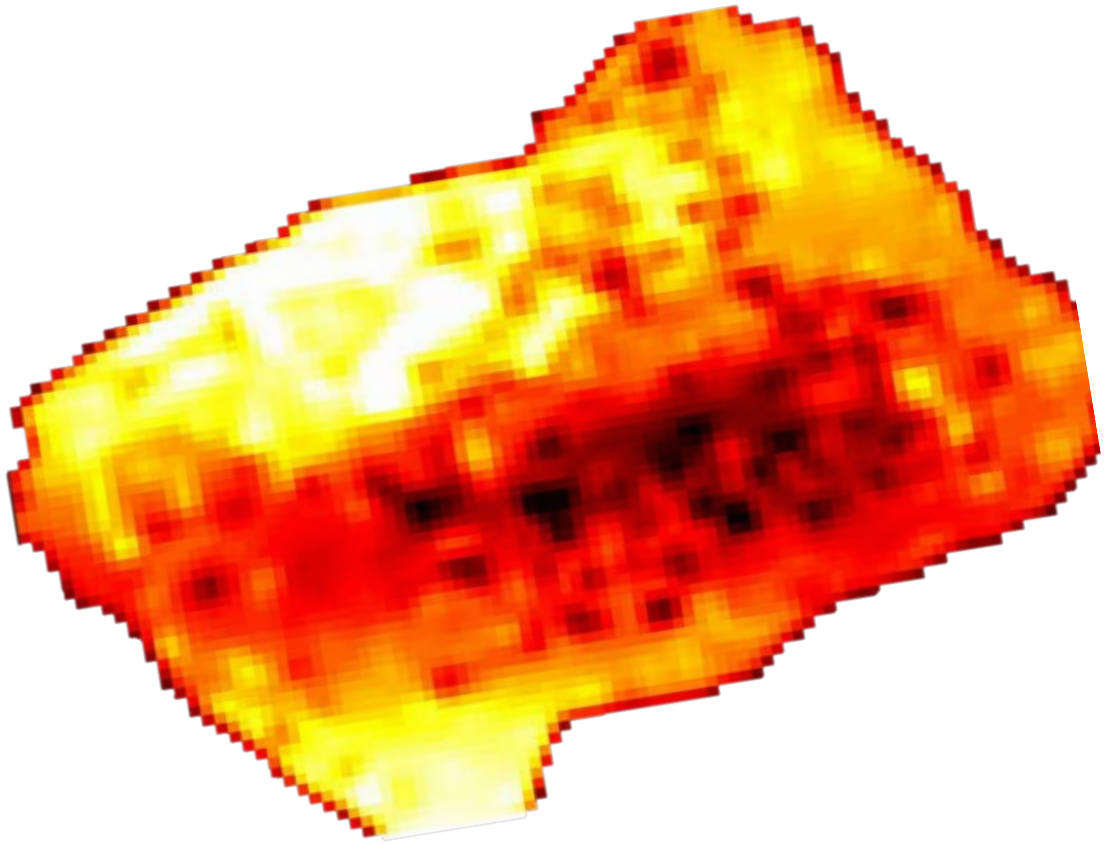
Cow excreta

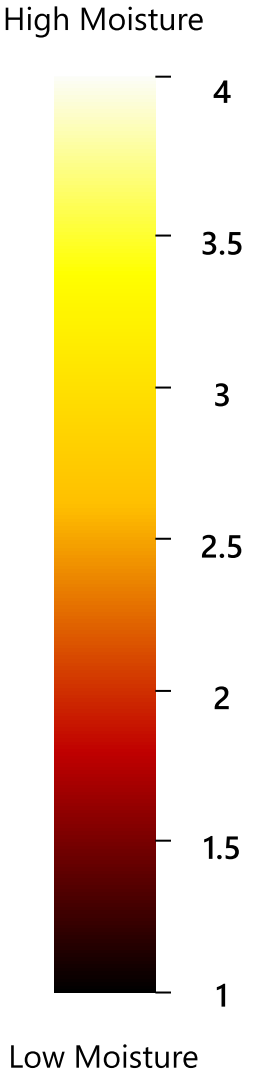
Cow herd

Stray cow

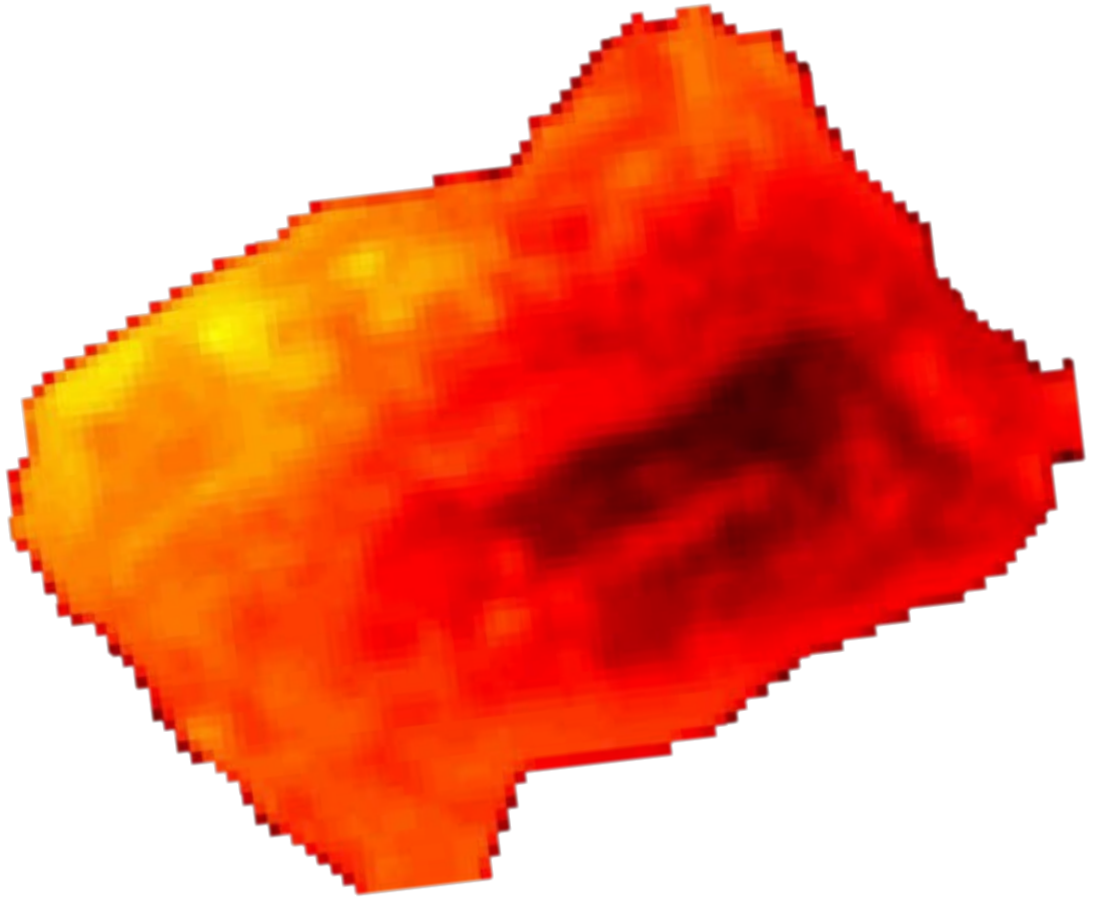
Precision Map: Panorama Generation

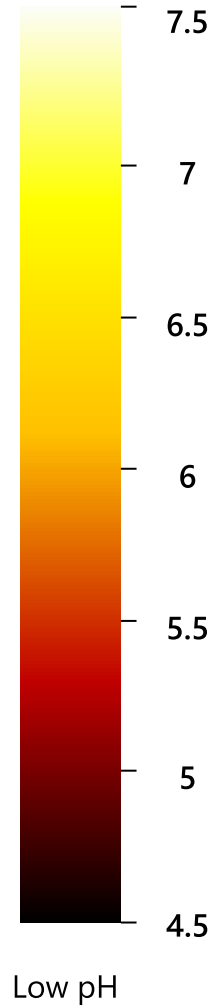
Precision Map: Moisture





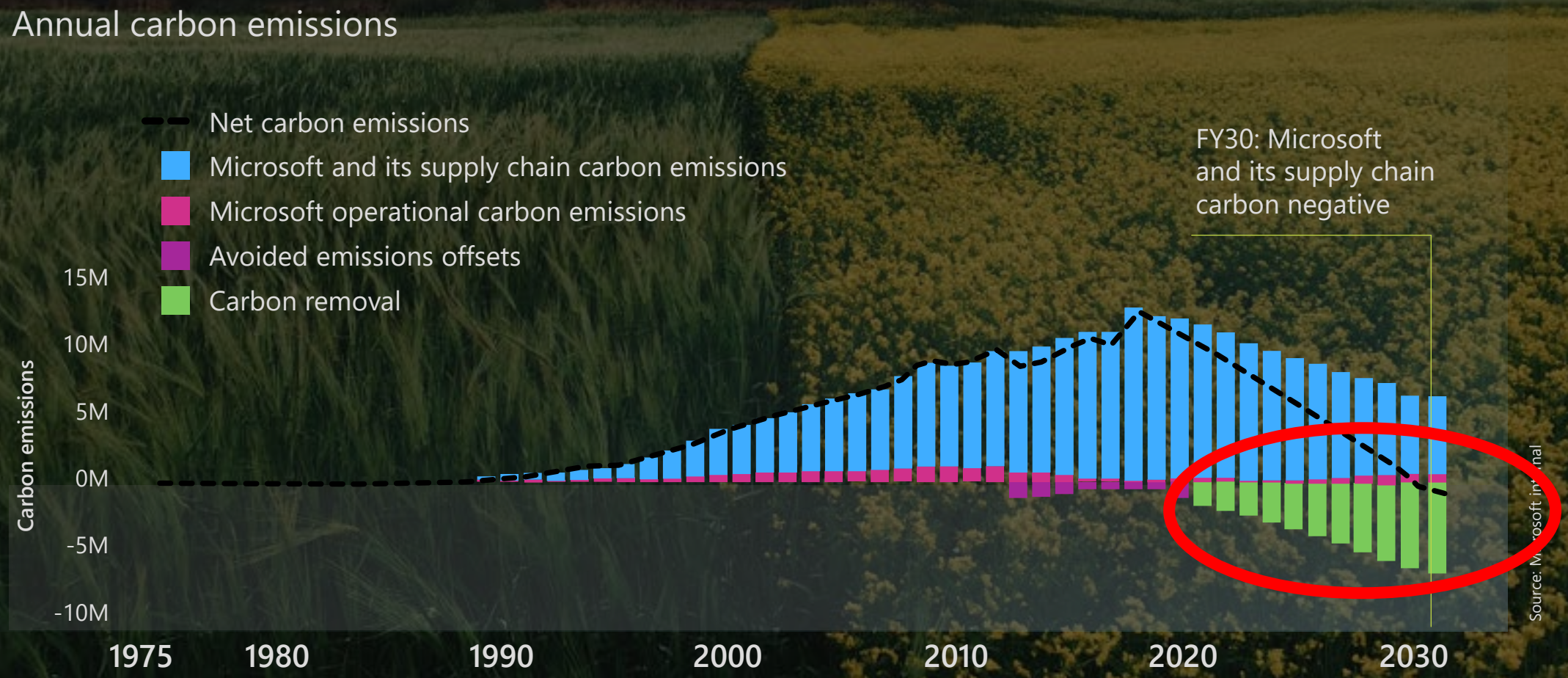
Precision Map: pH



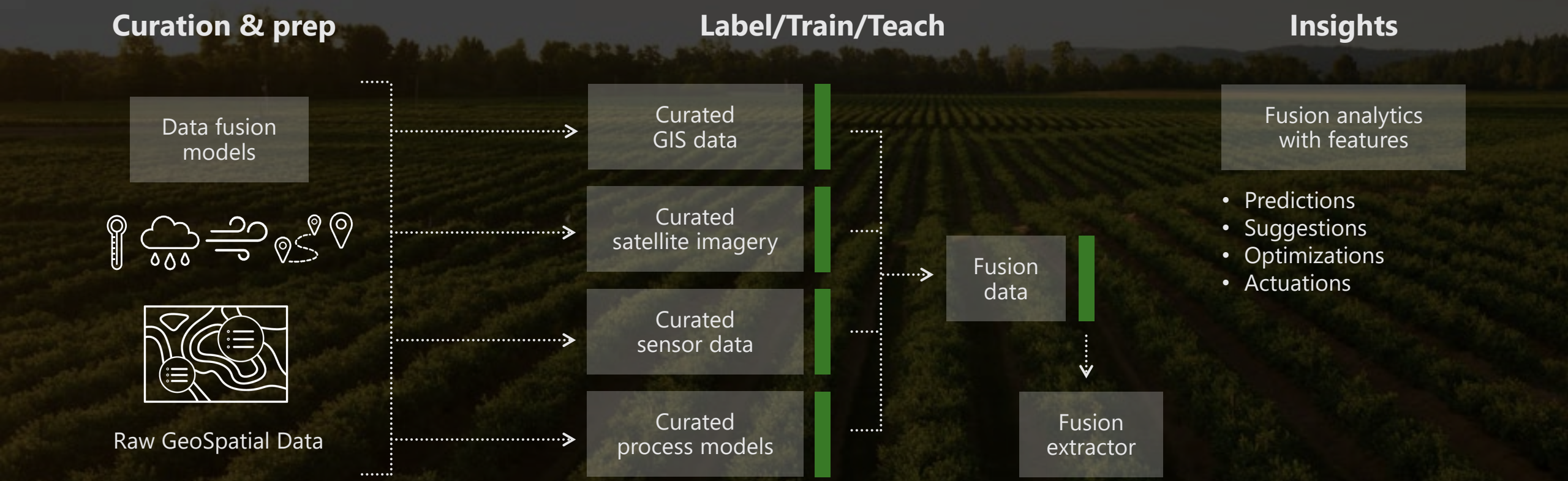


Sustainability: Beyond Reduction – Carbon Negative by 2030

Microsoft's pathway to carbon negative by 2030



Our Ag Carbon Platform: Project FarmVibes.ai



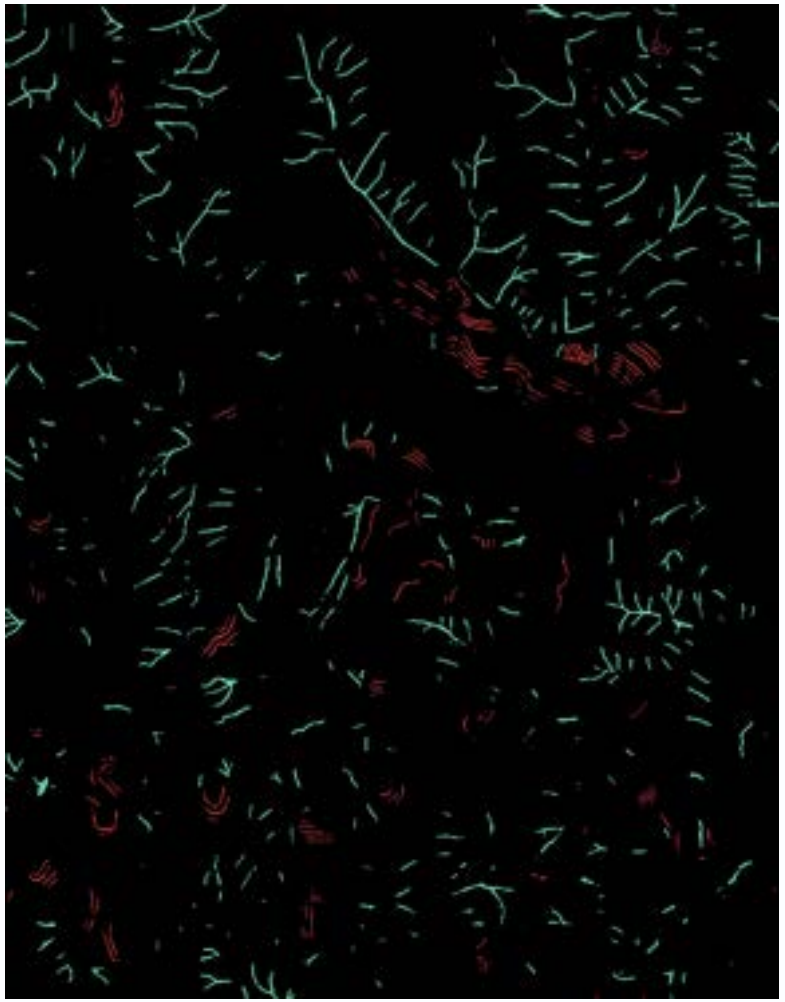
Demo: Agronomists' Tools for Carbon Footprint Reduction

Conservation practice classification

Terraces and grassed waterways make over 80% water management practices LoL takes into account when working with farmers

NAIP Imagery (Iowa)

Digital Elevation Map



Predicted Grassed Waterways & Terraces

GeekWire NEWS JOBS EVENTS RESOURCES ABOUT Search

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.

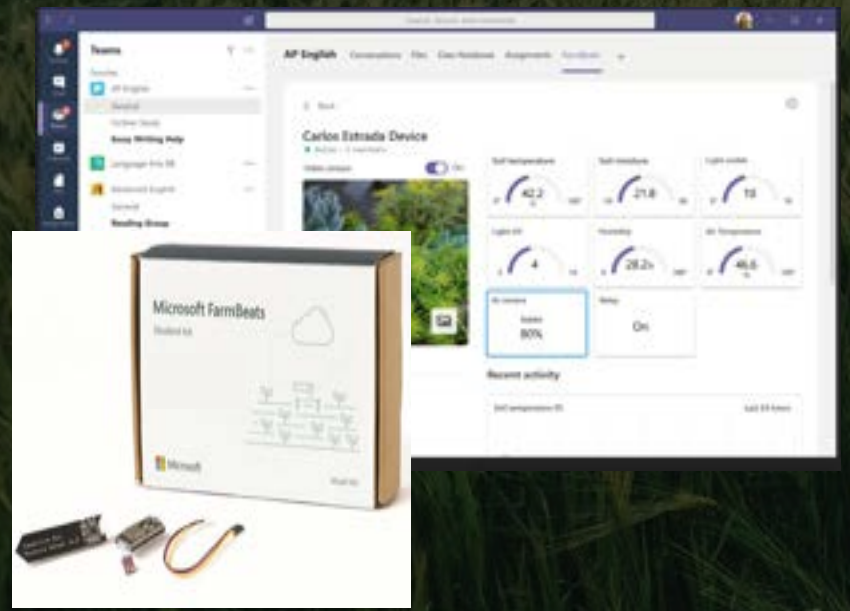
For Andrew, data is as important as dirt when it comes to agriculture. AI-powered technologies help reduce fertilizer use, forecast wind speeds, and identify soil moisture allowing farmers to reduce costs and boost yields.

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

Future Farmers of America + FarmBeats + FarmVibes

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



Affordable sensing
low-cost soil moisture and EC sensing using Wi-Fi

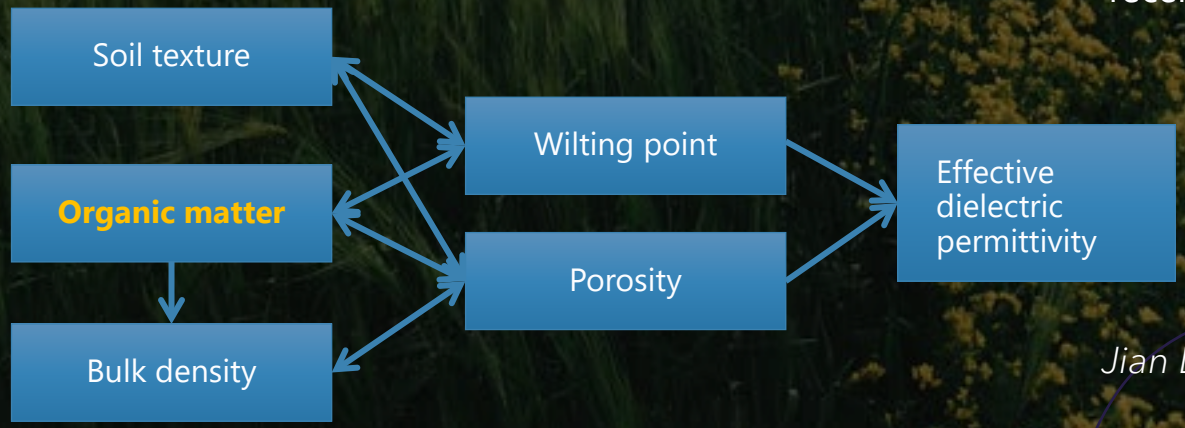
Motivation: existing sensors are expensive

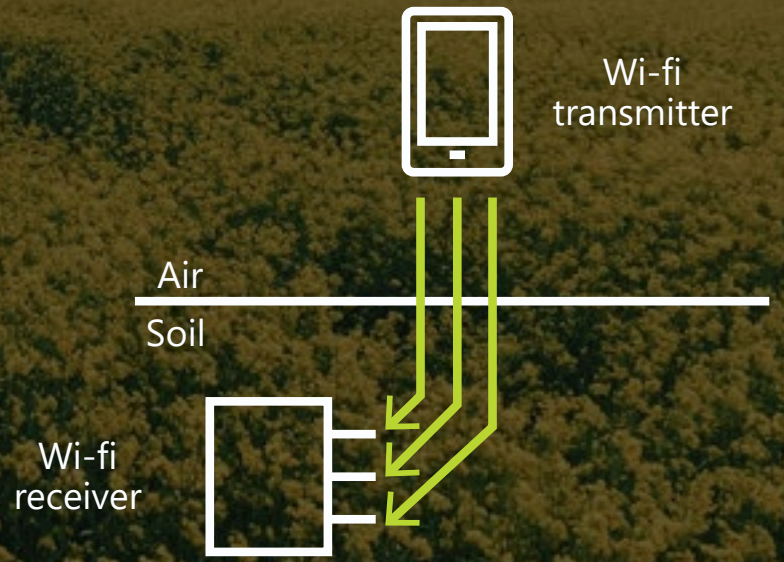
- ~100s of dollars

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

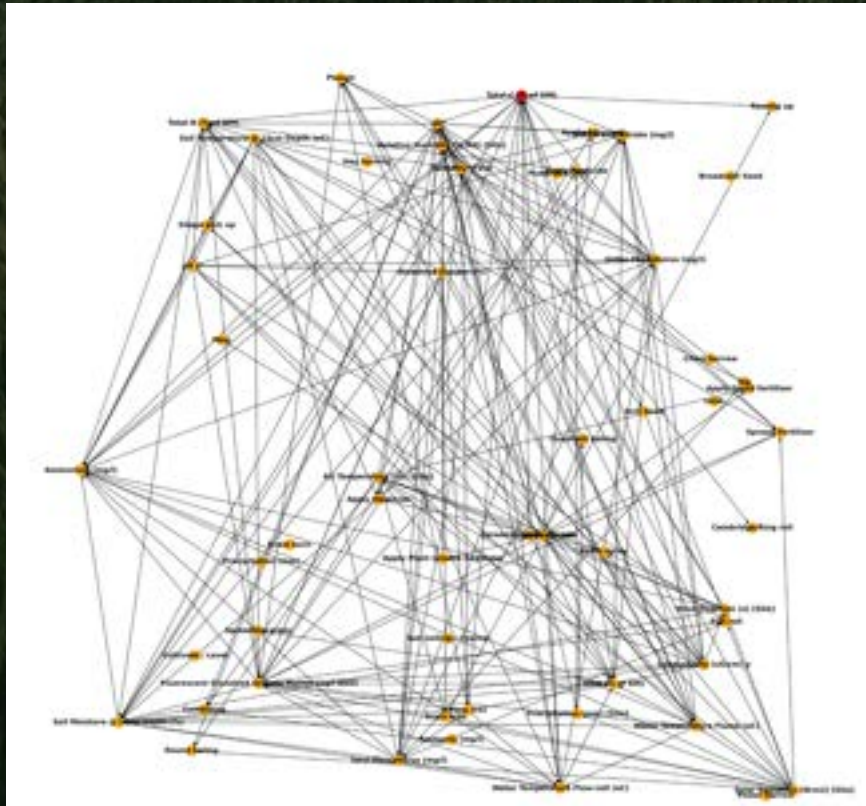




Jian Ding, Umesh Acharya, Rattan Lal, Ranveer Chandra

Soil Carbon Modeling

Accurately models 78.6 % in changes in soil carbon using weather drivers, green house gas emissions, soil macro-nutrient information for test farms



Causal Graph

Our Goal:

1. Model cause-and-effect relationship among soil processes.
2. Identify factors that cause changes in soil carbon.
3. Customizing process models for region-specific modeling

Machine Learning Paradigm:

Explicitly learn **cause and effect** relationships.

Incorporate **spatial-temporal** correlations.

Use **domain knowledge** to guide learning.

Example of Discovered Relations:

Discovered Causal Relations	Reasoning
Soil Temperature → Soil Carbon	Higher temperatures decomposes organic carbon
Soil Nitrogen → Soil Carbon	Nitrogen and Carbon co-metabolize in soil
Dissolved Oxygen → Soil Carbon	Dissolved oxygen in soil improves the organic matter content