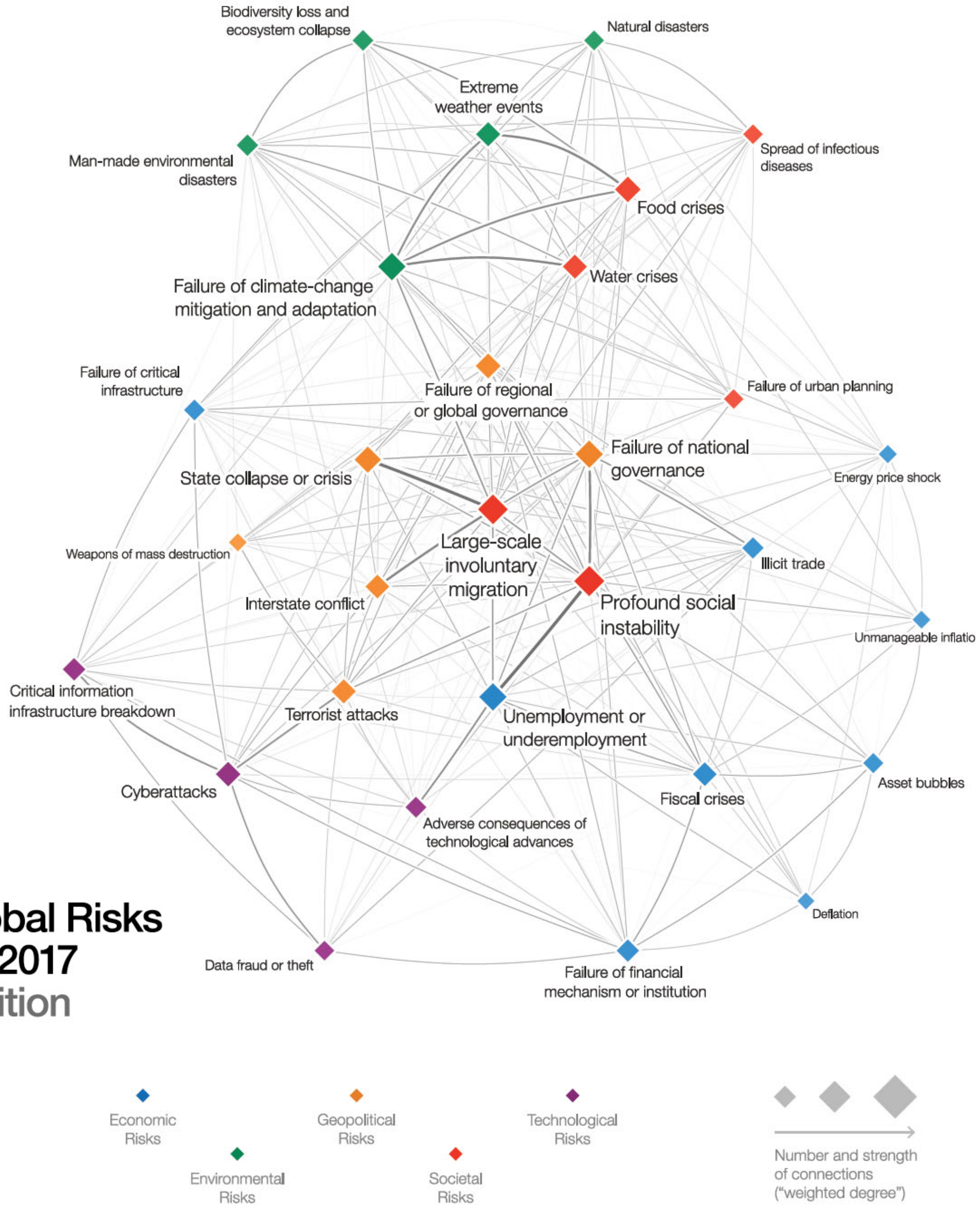
IoT – Agriculture,

The iota in the alphabet soup?

Walter Stiers
IBM Belgium

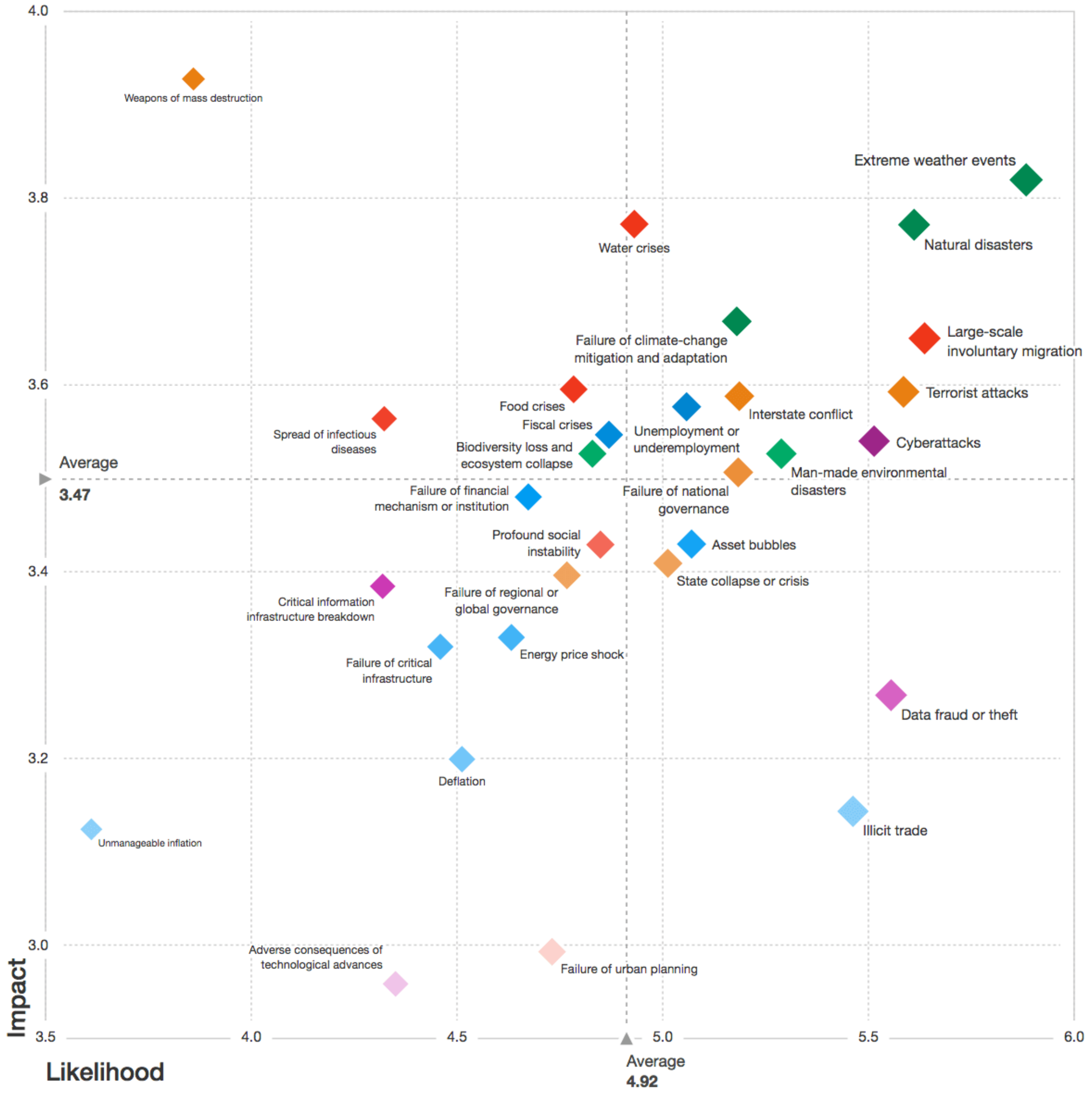
The Global Risks Report 2017
12th Edition

Source: World Economic Forum

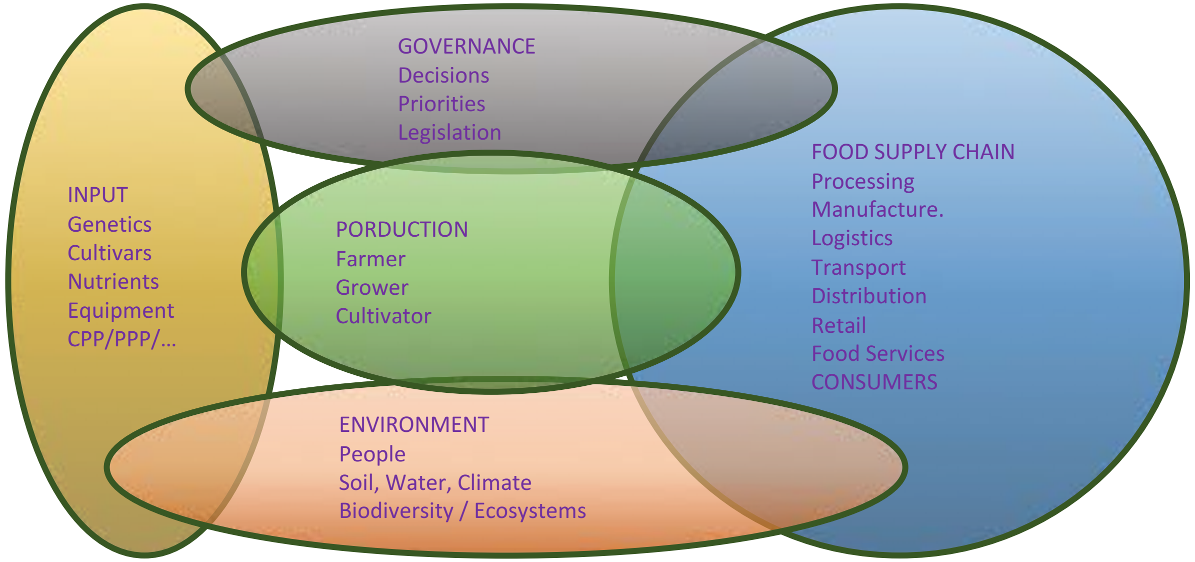


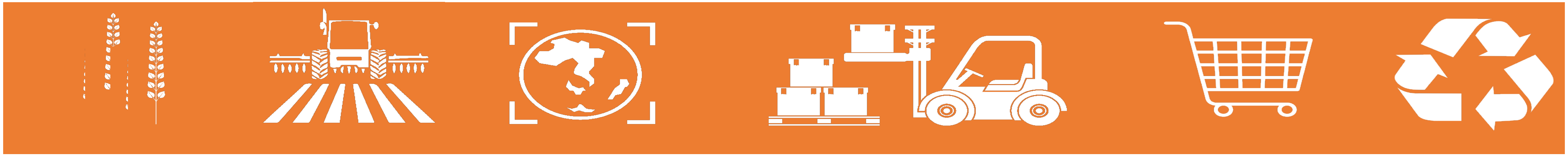
The Global Risks Landscape 2017

What is the impact and likelihood of global risks?



How IBM defines 'agribusiness'





Inputs

Seeds, fertilizer, crop protection, animal health, nutrients, equipment

Farmland & livestock management

Crops, dairy, proteins (animal and plant sources)

Trading

Crops, oils, animals, biofuels

Primary Processing and Logistics

Milling, bulk food ingredients, flavours, fragrances

Food and Fuel Manufacture

Foodstuffs, beverages, meat products, dairy, supplements

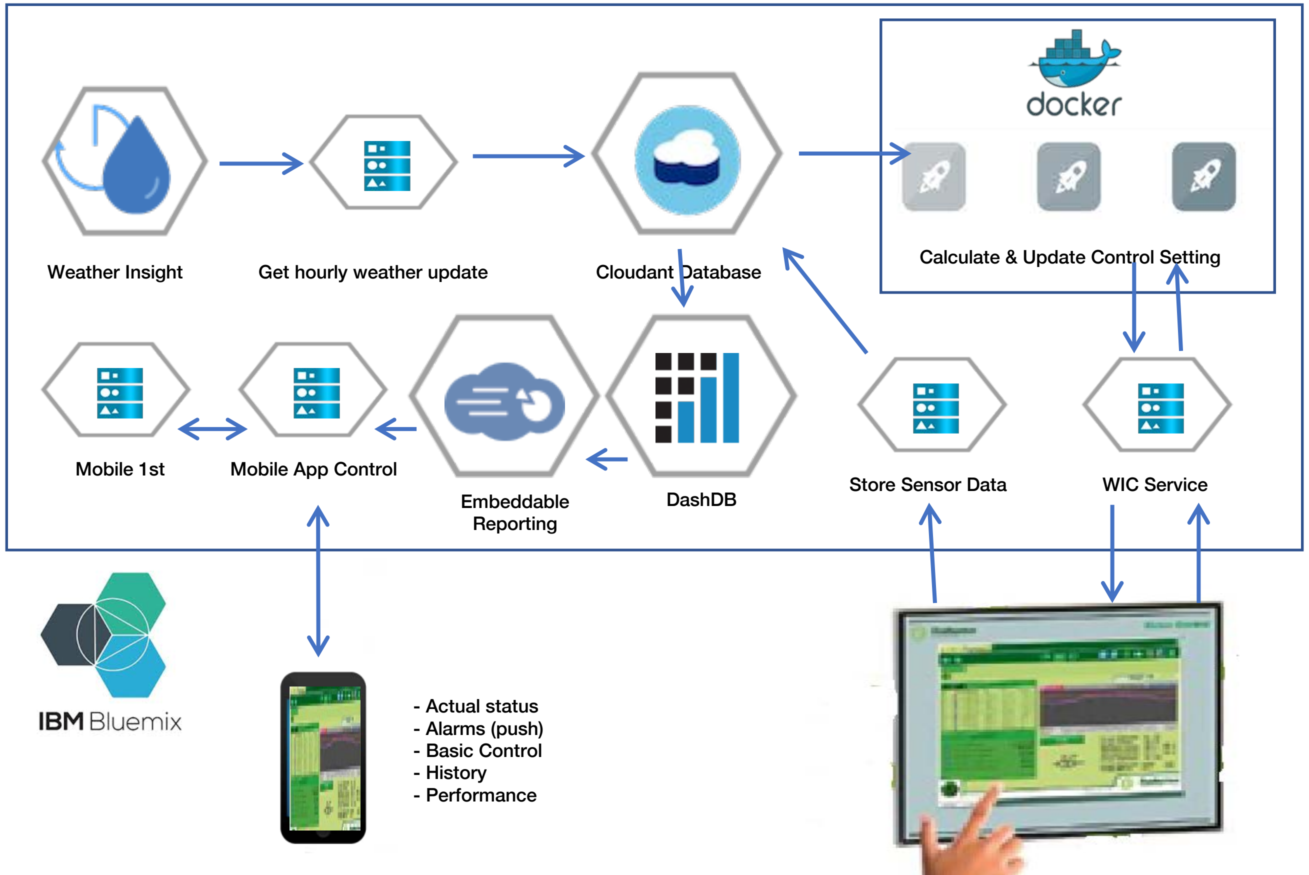
Distribution & Retailing

Traditional trade, modern trade, retailing

Post Consumption Processing

Recycling, upcycling, disposal

- Market leader in
  potato storage condition control systems
- Enhancing climate control for agriculture storage systems with energy management and weather forecasting data.
- Providing optimal & economic potato storage conditions using local weather forecasts on an hourly base



E&J Gallo Winery

Scalable Analytics: Improving crop yield and quality while reducing water consumption in the vineyard

Gallo & IBM:
2014 Vintage Report Innovation Award for prototype system
20 Jan. 2015

The challenge:

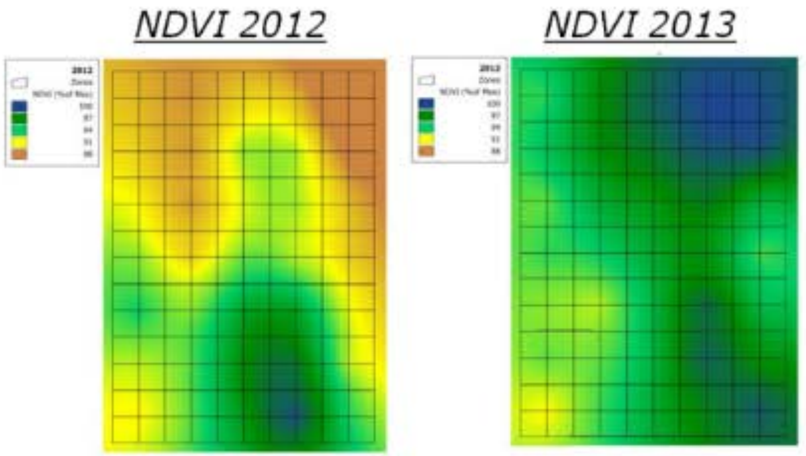
- Improve Crop yields and grape quality by precision irrigation solution
- Conserve water due to drought

Solution:

- Remote Satellite image processing for normalized vegetation index (NDVI)
- Evapo-transpiration modeling & plant modeling to determine irrigation schedule

Results:

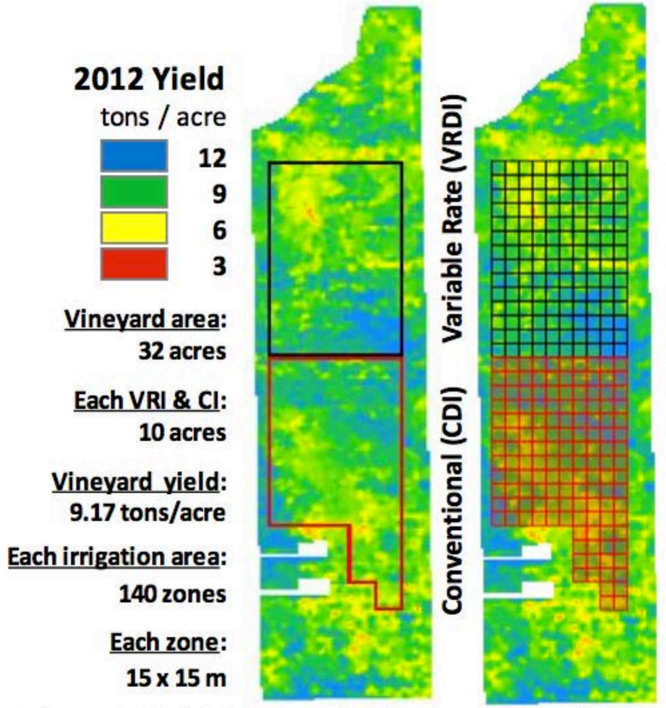
- Increased Yield 23%
- Water conservation 20%
- Reduced variability, 10% higher grape quality



2013- average NDVI is 0.76
2012- average NDVI was 0.7

Table 2. Average yield and water use efficiency of variable rate and conventional irrigation in all four years of the study

Year	Yield (tons/acre) VRI	Yield (tons/acre) CI	Gain VRDI/CDI (%)	WUE (tons/acre-foot) VRI	WUE (tons/acre-foot) CI	Gain VRDI/CDI (%)
2012	8.9	8.9	0.0	5.93	5.93	0.0
2013	7.7	7.4	4.1	5.63	4.93	14.2
2014	10.1	8.7	16.1	7.43	7.08	4.9
2015	5.1	4.6	10.9	4.27	3.65	17.1
Average			10.3			12.1

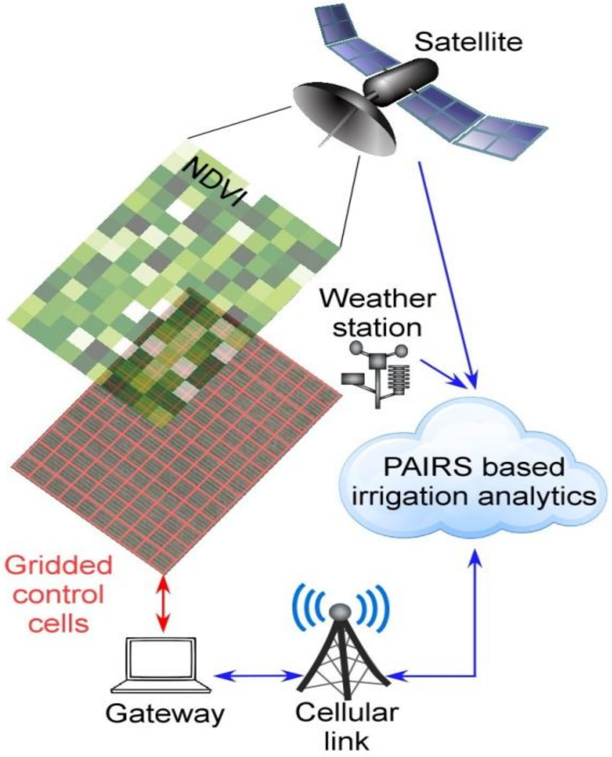


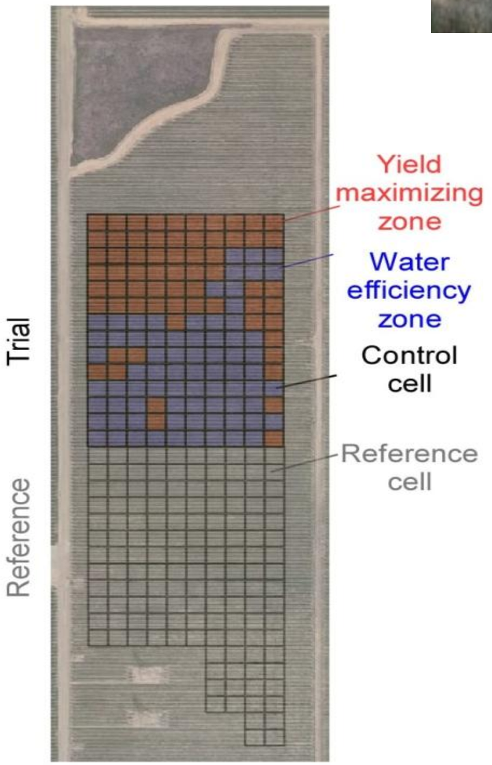
Scalable Analytics: Improving crop yield and quality while reducing water consumption in the vineyard

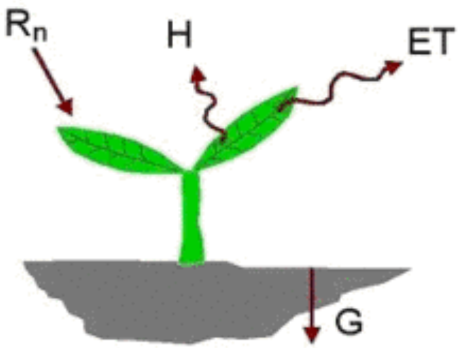
- Predictive weather model
- Weather station data
- Evapo-transpiration modeling
- *Control a smart variable rate irrigation system*

" The solution provides a precise and environmentally conscious method of increasing our grape yield and fruit quality while conserving water. "

Luis Sanchez,
senior research scientist – Gallo







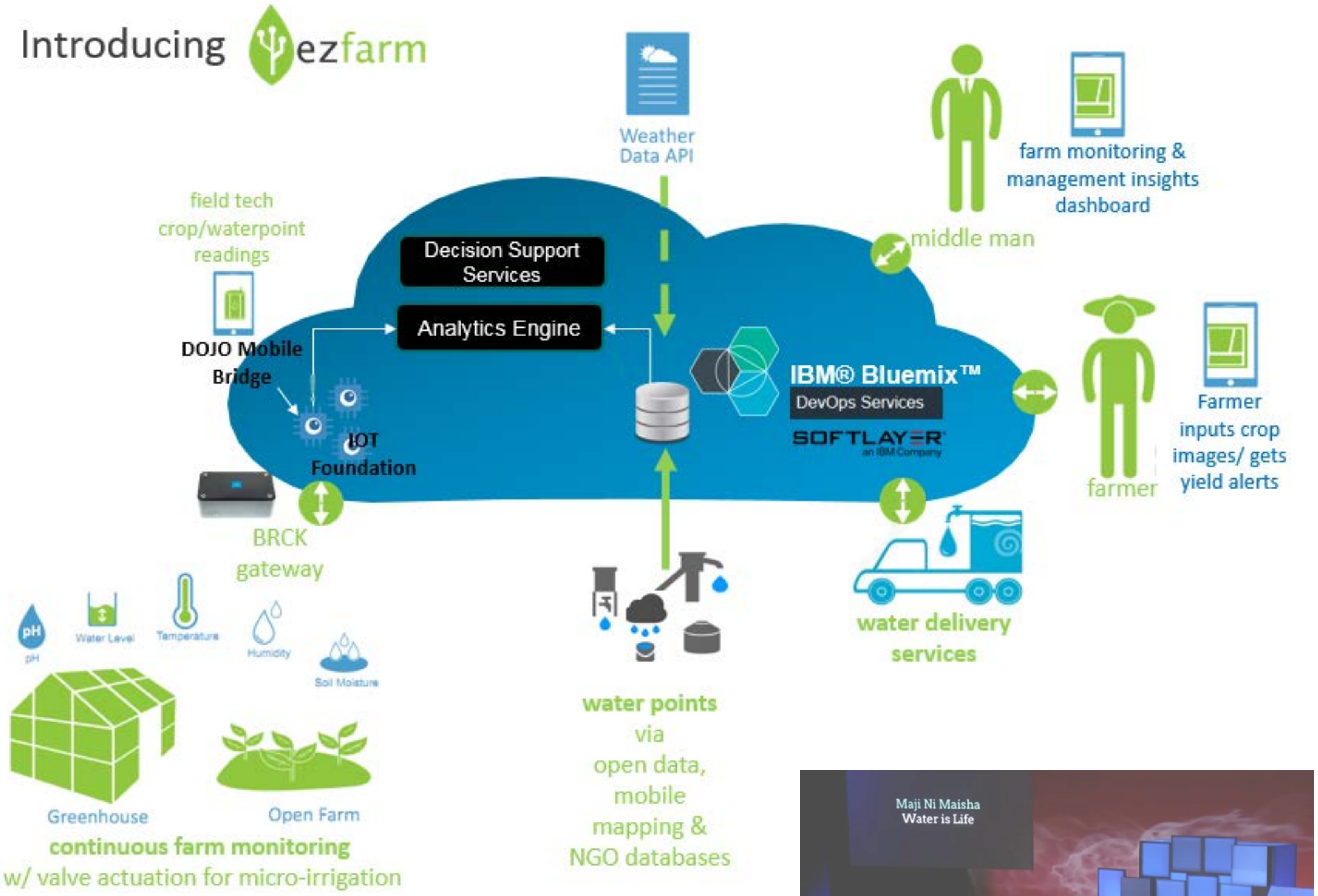
Energy Balance model:

$$ET = R_n - H - G$$

ET Evapo transpiration
R_n Net radiation Flux (W/m^2)
H Sensible heat Flux (W/m^2)
G Soil heat Flux (W/m^2)

Double drip line with control electronics.

EZ-Farm



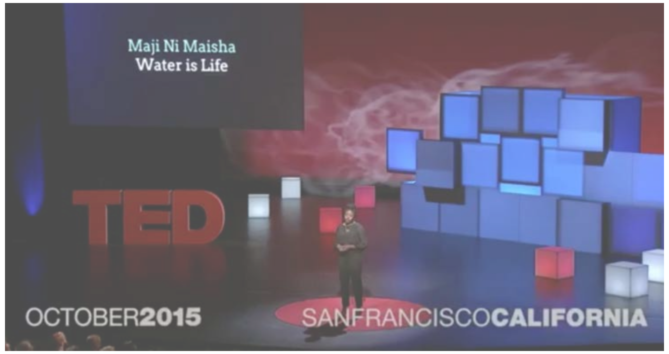
IBM Research created EZ-Farm, an Internet of Things (IoT) remote monitoring solution that helps small-scale farmers to better manage water resources.
Purpose is to eliminate water supply as an inhibiting factor to crop yields in Africa.

EZ Farms uses

- IBM Bluemix and
- IBM IoT Foundation

to enable sensors on the field that inform

- the small-scale farmers to better manage water situation
- agricultural aggregators to identify the best prospects for financing.

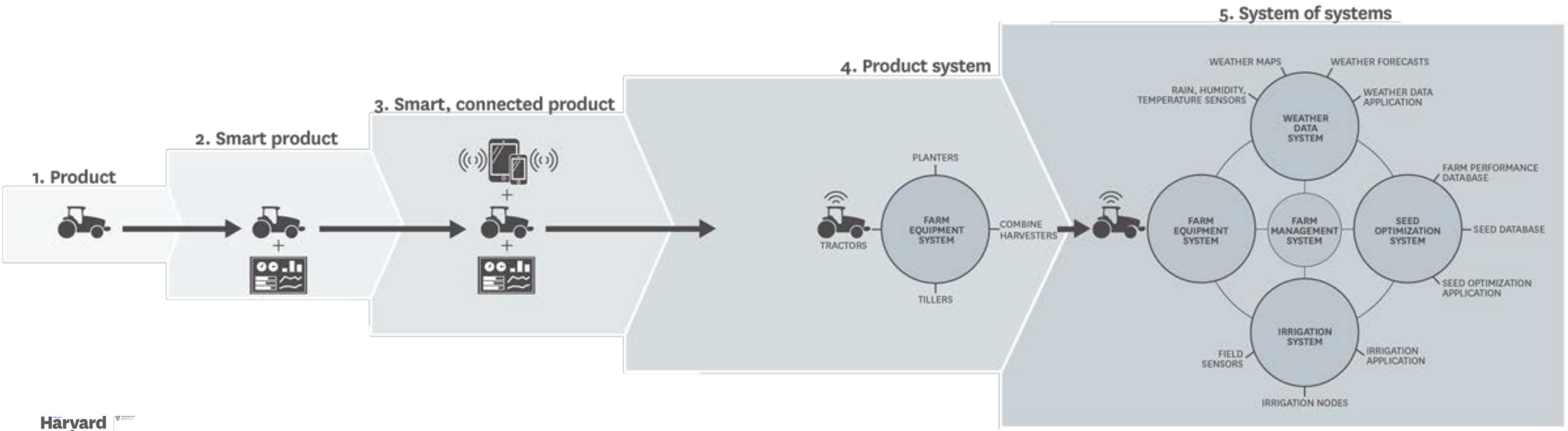


Kala Fleming:
Easing water scarcity by understanding when and where it flows

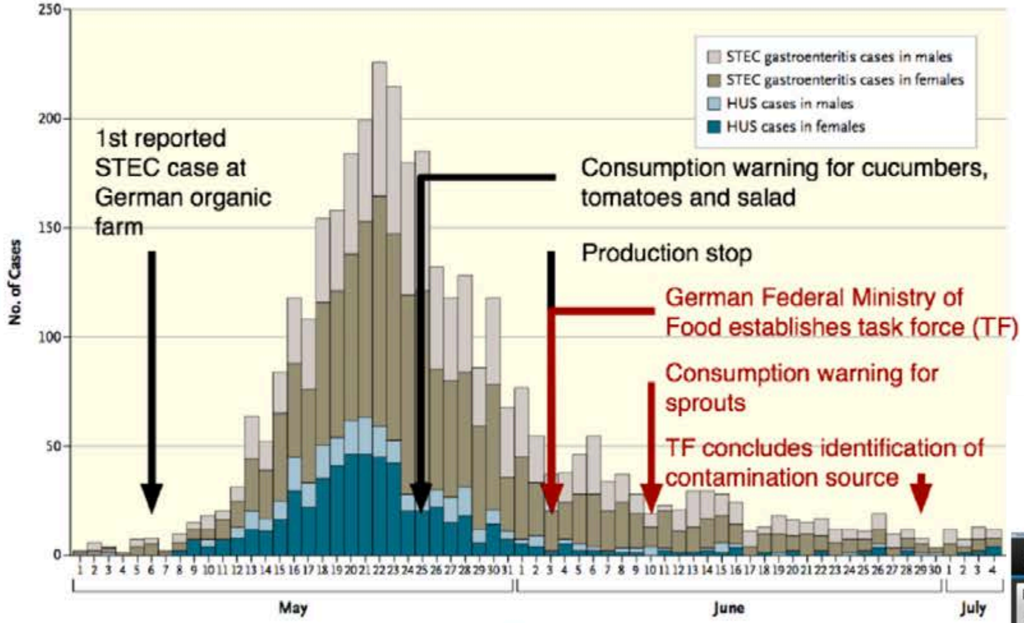
How Smart, Connected Products Are Transforming Companies

Michael E. Porter James E. Heppelmann

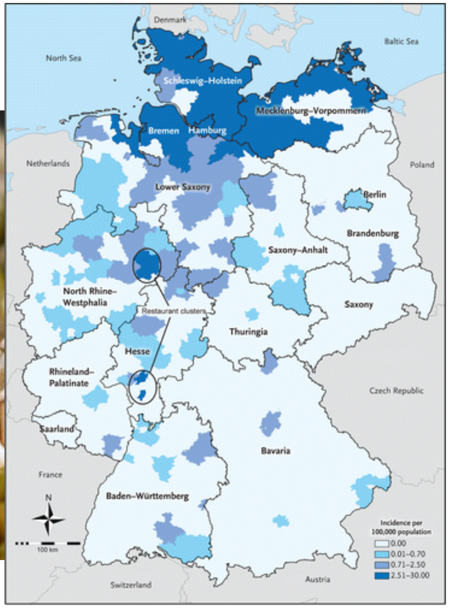
Harvard Business Review, November 2014



EHEC/STEC 2011 Outbreak in Germany



(source: Frank *et al.*, New Engl J Med, 2011; Ergebnisbericht der Task Force EHEC zur Aufklärung des EHEC O104:H4 Krankheitsausbruchs in Deutschland, 2011)

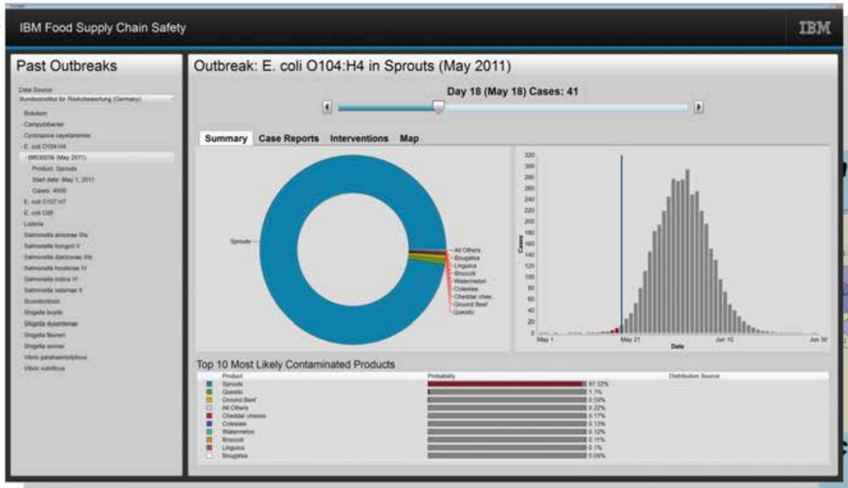


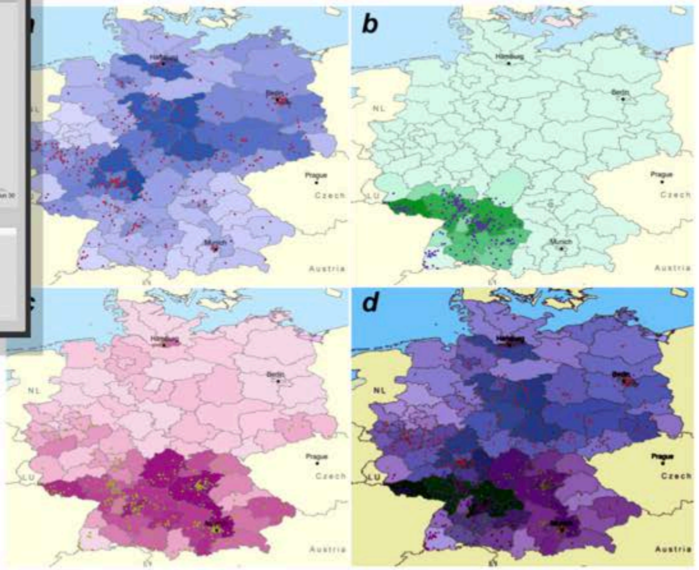
Can we prepare for investigation of a food-borne disease outbreak … before it even occurs?

Figure 1: The Farm-to-Fork Road Map[1] including the entire food product supply chain of agriculture, transportation, processing, packaging and consumer.

Likelihood Based Method

Identification of "suspect product set"





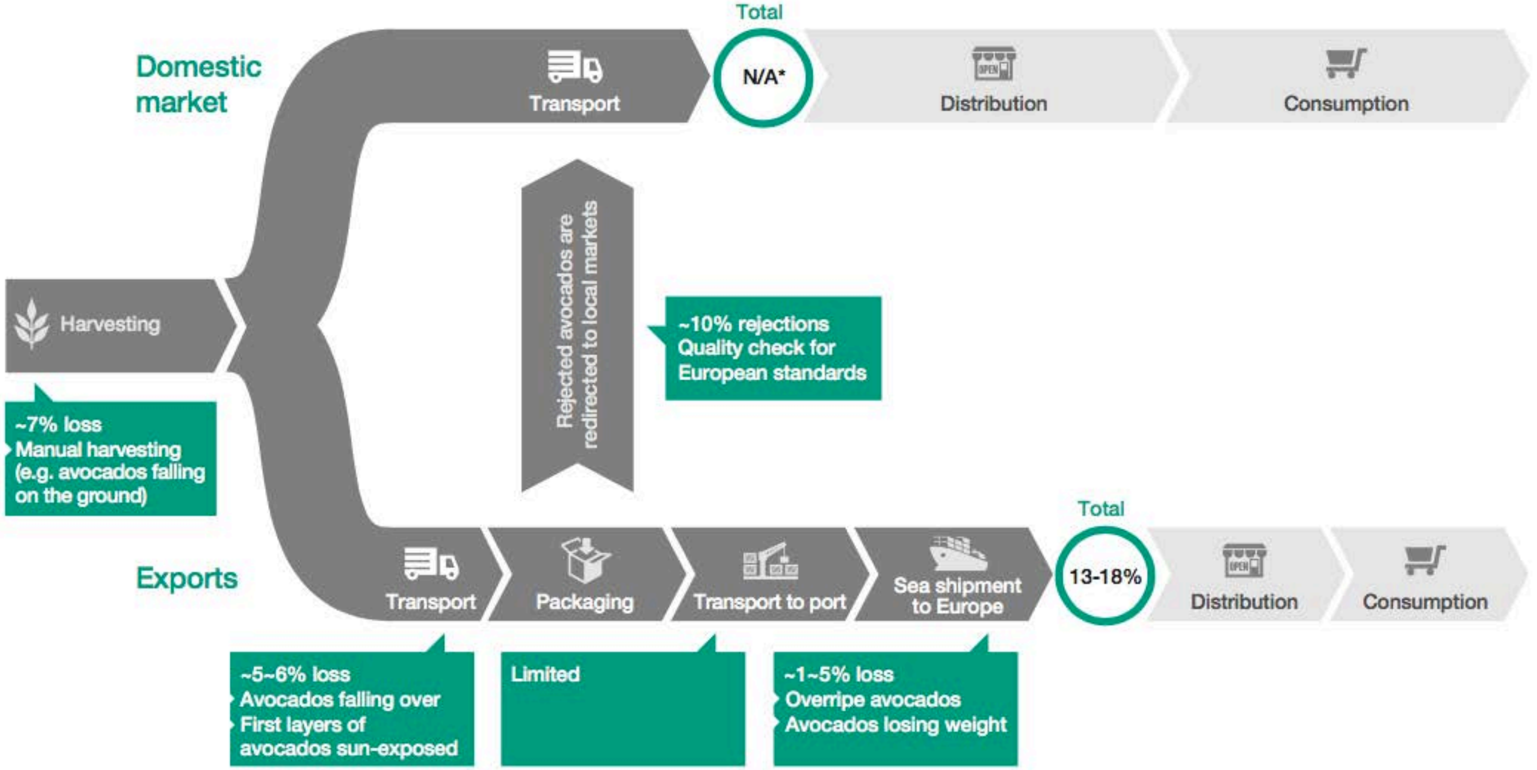
- Collaboration with IBM Research and the German Federal Institute for Risk Assessment (BfR)
- Comparing Sales Distributions to Outbreak Patterns

J.H. Kaufman et al., "A Likelihood-Based Approach to Identifying Contaminated Food Products Using Sales Data: Performance and Challenges." *PLoS computational biology* 10.7 (2014): e1003692.



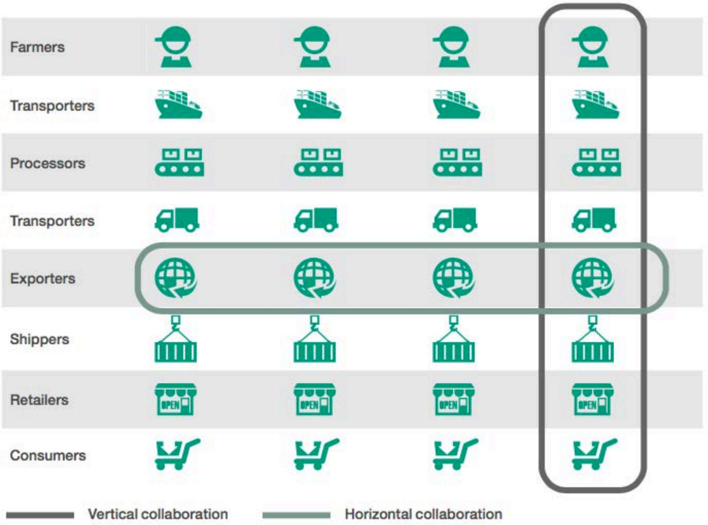
Figure 32 Avocados Are Trans-shipped in Oman

Figure 34: Food Loss in Kenyan Avocado Value Chains (Estimates)



Source: Interviews

Figure 37: Both Vertical and Horizontal Collaboration within a Value Chain are Important (Illustrative)



WORLD ECONOMIC FORUM
COMMITTED TO IMPROVING THE STATE OF THE WORLD

Enabling Trade: From Farm to Fork

January 2014

Hungry Planet: What the World Eats

Peter Menzel
Faith D'Alusio

Bhutan: The Namgay family; Chad: The Aboubakar family; Ecuador: The Ayme family; and Germany: The Melander family by 7_70 are licensed under CC BY 2.0 via Flickr

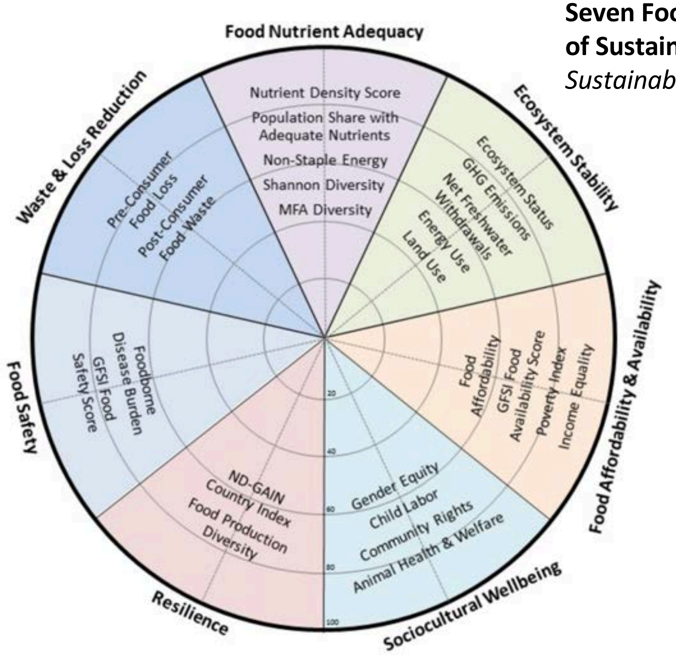
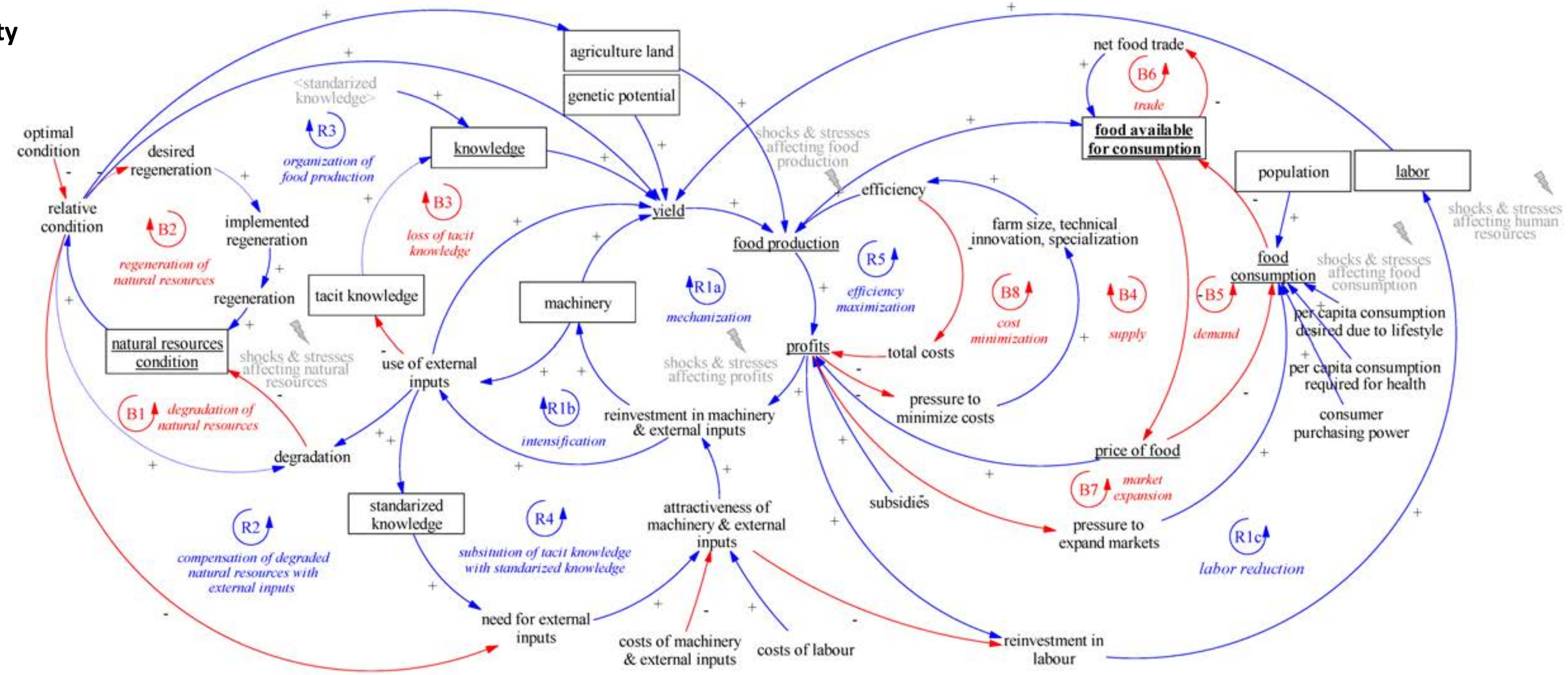
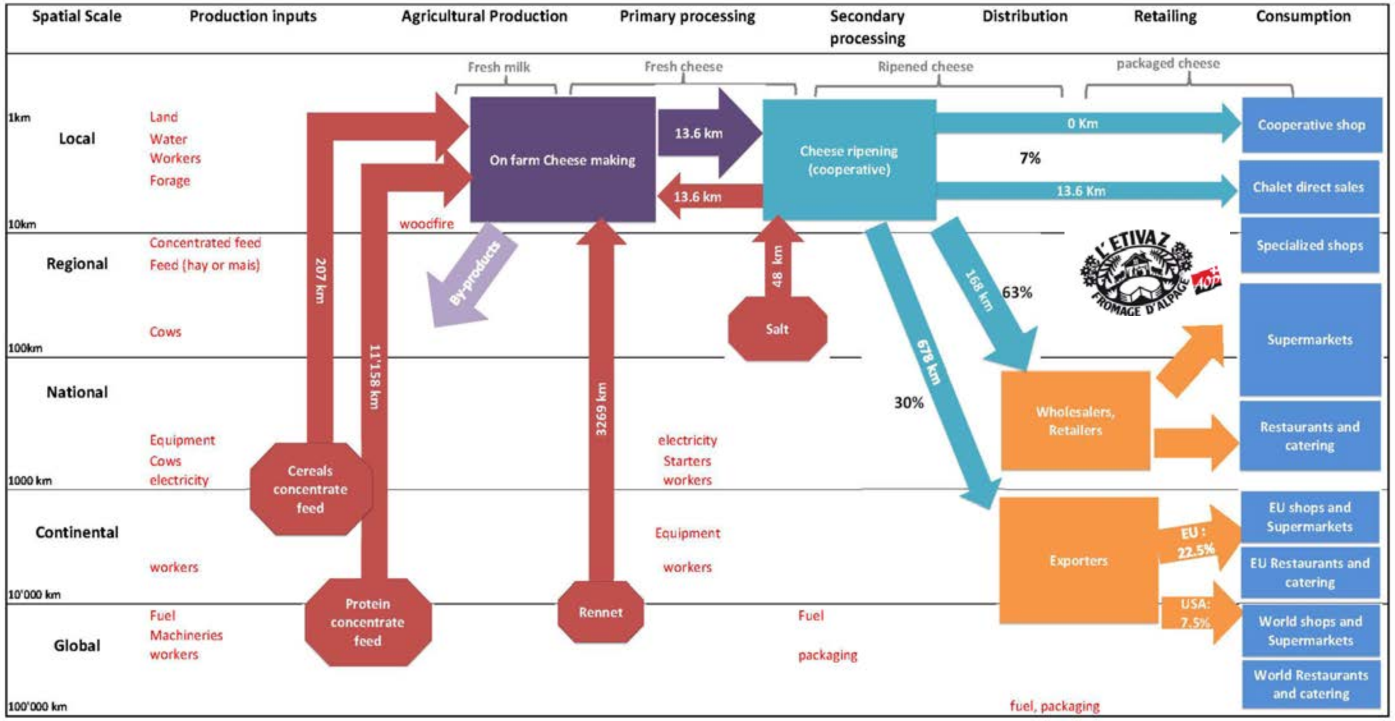


Figure 1. Food system metric indicators.

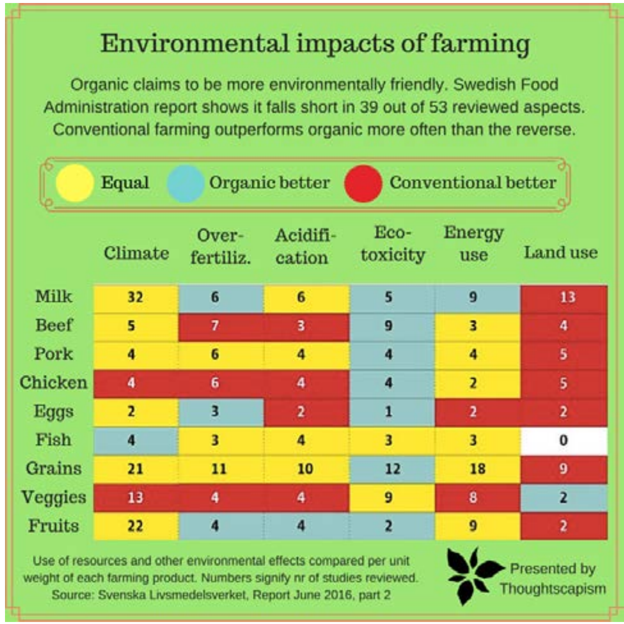
Seven Food System Metrics of Sustainable Nutrition Security
Sustainability **2016**, *8*, 196;





Integrated causal loop diagram of the conventional European food system with indicated exemplar entry points for external drivers of change;
Can Organic Farming Reduce Vulnerabilities and Enhance the Resilience of the European Food System? A Critical Assessment Using System Dynamics Structural Thinking Tools
Sustainability **2016**, *8*, 971

L'Etivaz value chain spreading between the local and the global scale.
Are Local Food Chains More Sustainable than Global Food Chains? Considerations for Assessment
Sustainability **2016**, *8*, 449;


Environmental impacts of farming

Organic claims to be more environmentally friendly. Swedish Food Administration report shows it falls short in 39 out of 53 reviewed aspects. Conventional farming outperforms organic more often than the reverse.

Equal | Organic better | Conventional better

	Climate	Over-fertiliz.	Acidifi-cation	Eco-toxicity	Energy use	Land use
Milk	32	6	6	5	9	13
Beef	5	7	3	9	3	4
Pork	4	6	4	4	4	5
Chicken	4	6	4	4	2	5
Eggs	2	3	2	1	2	2
Fish	4	3	4	3	3	0
Grains	21	11	10	12	18	9
Veggies	13	4	4	9	8	2
Fruits	22	4	4	2	9	2

Use of resources and other environmental effects compared per unit weight of each farming product. Numbers signify nr of studies reviewed. Source: Svenska Livsmedelsverket, Report June 2016, part 2

Presented by Thoughtscapism

IBM Research: 5-in-5

Macroscopes will help us understand Earth's complexity in infinite detail

Organize the IoT

New tools like macroscopes will organize all the world's data -- whether gathered by microscopes, telescopes or everything in between.

Transform industries

Macroscopes will reveal new insights about some of the most fundamental problems we face, such as the availability of food, water and energy.

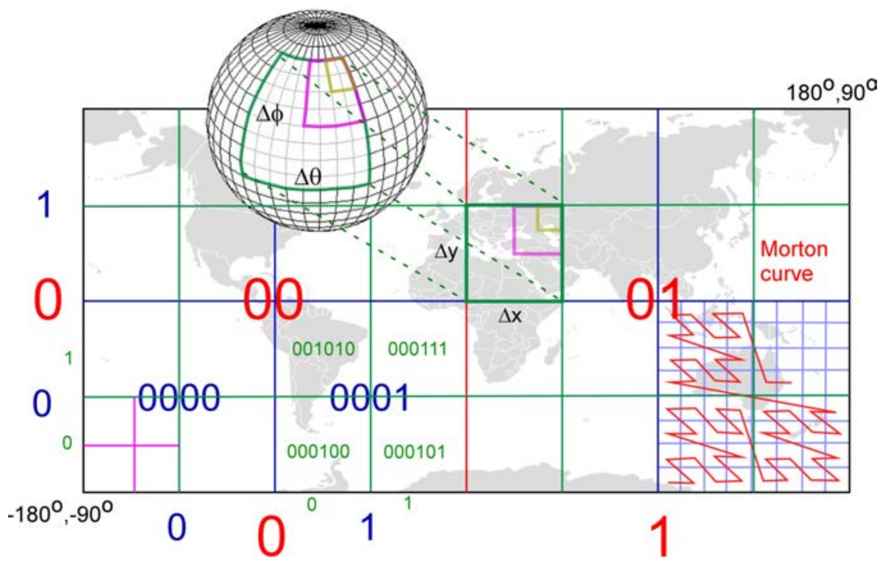
Search data by time and space

Macroscope technology will be built on platforms that collect and curate geospatial data so it can be easily searched.

http://www.research.ibm.com/5-in-5/macroscopes/

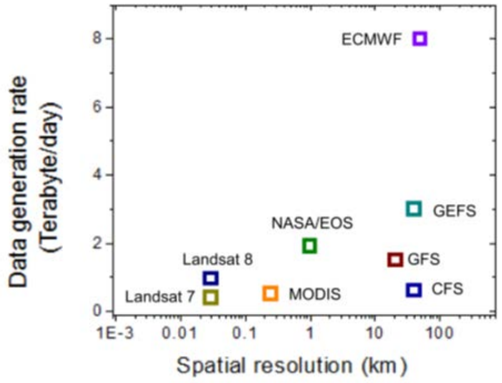
Towards large-scale crop production forecast for global food security

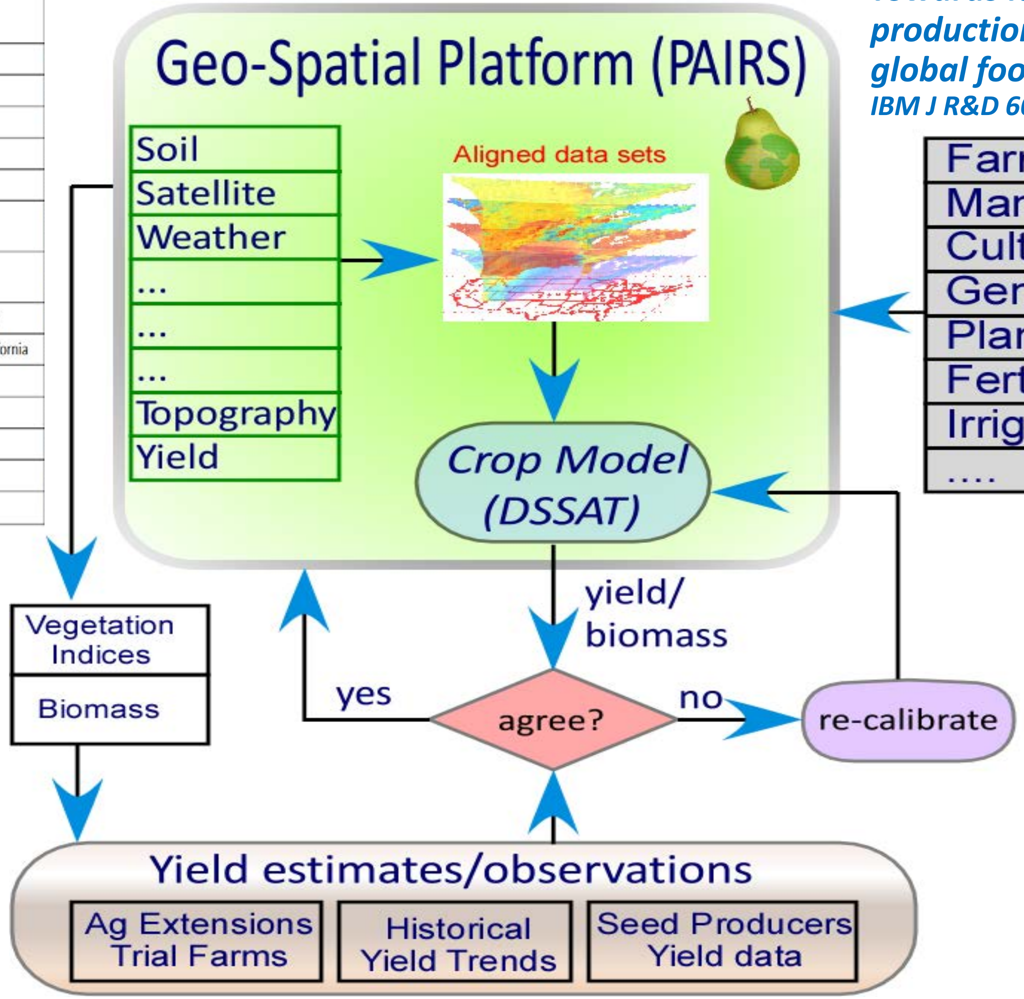
IBM J R&D 60 (5/6), 2016

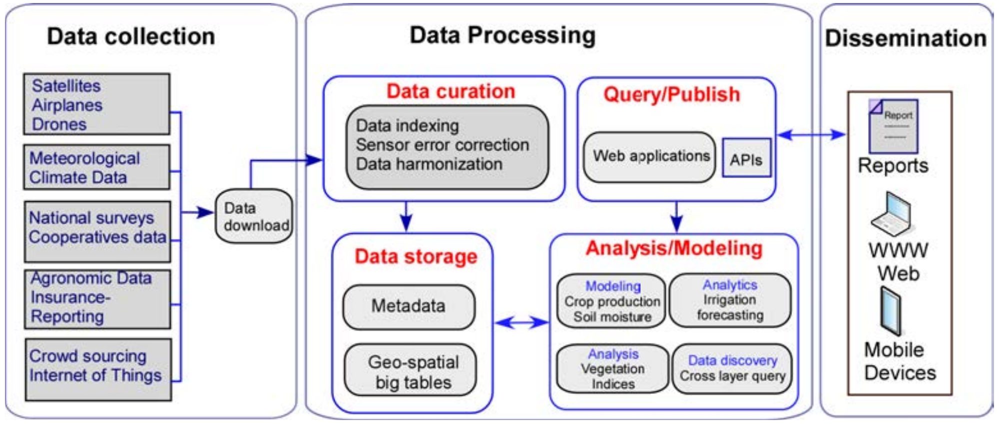


	Datasets	Origin
Satellite	Landsat 7	USGS
	Landsat 8	USGS
	Modis /Vegetation Product	NASA
	Modis Surface Reflectance	NASA
Weather	Global Forecasting System(GFS)	NOAA
	North American Mesoscale Forecast System (NAM)	NOAA
	European Centre for Medium Range Weather Forecast (ECMWF)	EU
	PRISM data	U of Oregon
	CIMIS data	State of California
Survey	National Elevation Data	USGS
	Soil data (SSURGO)	USDA
	Cland use (Cropscape)	USDA
Analytics	IBM Blended Forecast	IBM
	IBM Evapo-transpiration/ Irrigation	IBM

Resolution layers (n)	Δθ, ΔΦ [degree]	Δy [km] Δx [km] (Φ=0°)	Δx [km] (Φ=40°)
1	0.000008	0.00089	0.00067
2	0.000016	0.00178	0.00134
3	0.000032	0.00356	0.00268
4	0.000064	0.00712	0.00536
5	0.000128	0.01424	0.01072
6	0.000256	0.02848	0.02144
…			
9	0.002048	0.22786	0.17152
…			
26	268.43546	29863.444	22481.469





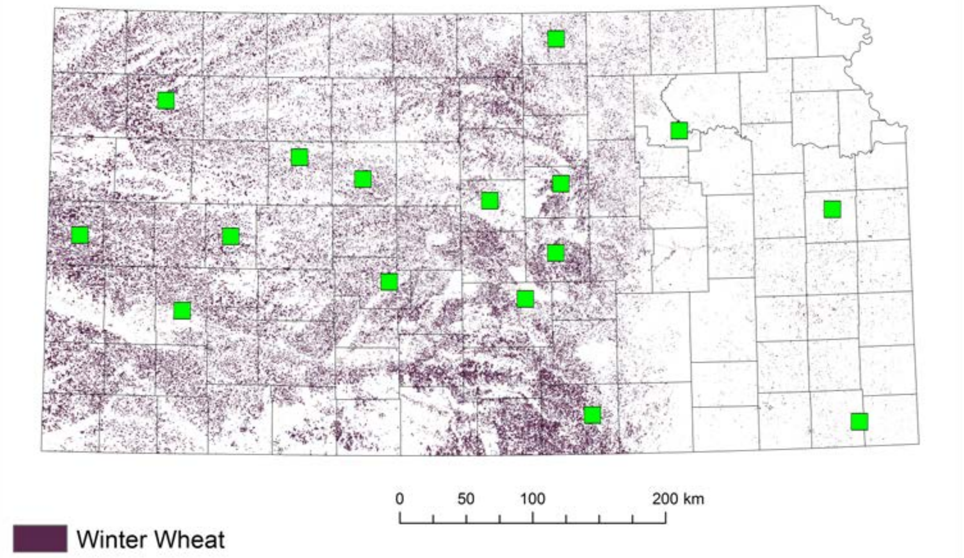


- Key is a combination of spatial and temporal information
- Global grid cell resolution spans from 0.8 m grid cell to 260 km grid cell
- All resolution layer are nested and aligned at lower left corner or cell grid

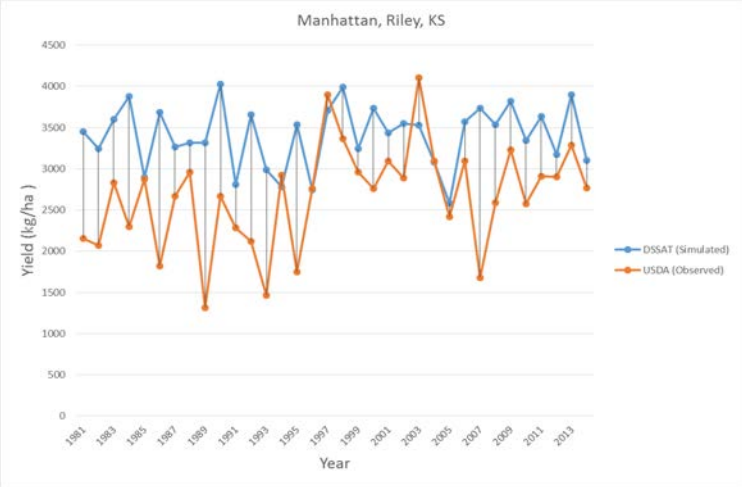
Soil	Weather	Crop Management
• pH, • Slope, • Albedo, • Run-Off, • Drainage Class, • Sand, Silt, Clay, • Organic Carbon, • 1/3 bar Buck Density • Horizon Depth	• Daily Temperature (Max and Min) • Daily Precipitation • Daily Solar radiation	• Irrigation regime • Fertilizer application • Plantation date and method • Harvest date • Cultivar(s) • Planting depth • Planting density • If rows (spacing)

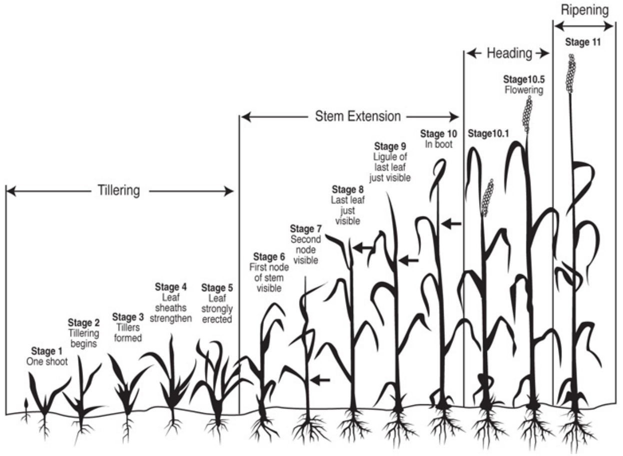
Decision Support System for Agrotechnology Transfer (DSSAT)

Kansas Study:

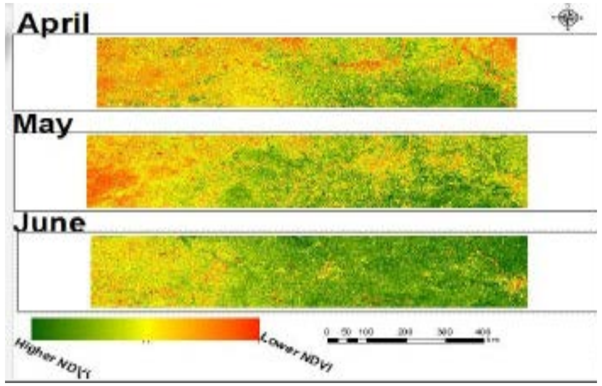


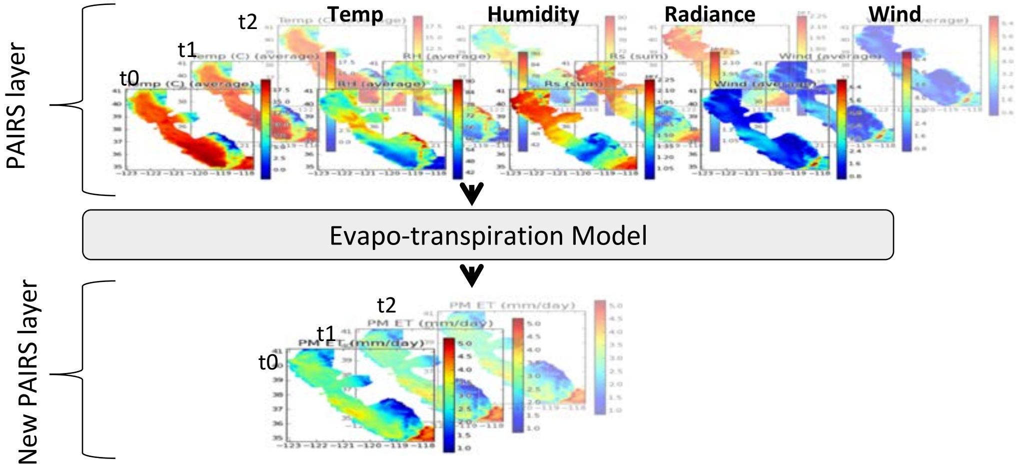
- Kansas, USA (213,000 Km^2)
- Elevation: 207 m to 1232m (average ~610m)
- The climate of Kansas can be characterized in terms of three types:
    - humid continental,
    - semi-arid steppe, and
    - humid subtropical
- Kansas has the largest change in weather conditions: west part irrigated - east part rain fed
- 8,800,000 acres harvested in 2014
- Second largest producer of Wheat in the US





- DSSAT simulation using PAIRS data:
    - Yield forecast – Anthesis date & Maturity date forecast
- Historical wheat yield simulation
    - One point in the county vs. the reported average yield for the county
    - The sub-objective was to check the general trend
- Seasonal analysis and various scenarios
    - Yield potential, impact of irrigation, N
- Satellite based vegetation index integration
    - NDVI-normalized difference vegetation index





CONCLUSIONS:

- Global crop production estimates require the combination of crop models (DSSAT) with big data platforms (PAIRS)
- PAIRS offers unique capabilities include complex cross-layer queries and data discovery
- Geospatial big data platforms to drive this modeling exist and are improving
- Training models on historical data is a challenge:
    - access to reliable data sets
    - domain knowledge integration
    - reusability of the information
- PAIRS can be used to improve forecasts (crop type, production yield, weather, etc.) relevant to commodity trading.
- PAIRS can be used to impact farming operations (optimized irrigation, fertilization, crop protection, etc.)

To conclude …

Agri-Food Supply Chain benefits from IoT,
taken into consideration:

The range, variety and complexity of the eco-system

The benefits from Cloud, Analytics & Shared Data

- Take benefit of different types of IoT data from the eco-system
  IoT^2: IoT outside Technology, e.g. terrain, soil, weather, genetics, satellite info, sales, …
- An IoT Framework to connect sensors and actuators on a PaaS platform
- Provide Access Rights, including granular security & privacy
- Detailed Analytics & Models, enhanced with cognitive services
  Build on data management, curation, statistics, physics based models, machine learning
- Blockchain for e.g. track & trace, provenance, fraud detection, …