IoT – Agriculture, The iota in the alphabet soup?

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The Global Risks Landscape 2017

What is the impact and likelihood of global risks?

The Global Risks Report 2017
12th Edition

Source: World Economic Forum
How IBM defines ‘agribusiness’

**Inputs**
- Seeds, fertilizer, crop protection, animal health, nutrients, equipment
- Farmland & livestock management

**Trading**
- Crops, dairy, proteins (animal and plant sources)
- 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.
Scalable Analytics: Improving crop yield and quality while reducing water consumption in the vineyard

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
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/m²)
- H  Sensible heat Flux (W/m²)
- G  Soil heat Flux (W/m²)
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

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

Figure 1: The Farm-to-Fork Road Map' including the entire food product supply chain of agriculture, transportation, processing, marketing 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

Figure 32: Avocados Are Trans-shipped in Oman

- Arrival in Antwerp (Belgium) in 25-40 days
- Trans-shipment in Salalah (Oman)
- Departure from Mombasa port
- Need to go wide of the Somali coasts due to piracy issues

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

- Domestic market: N/A
- Distribution: 13-18%
- Consumption

- Harvesting
- ~7% loss: Manual harvesting (e.g., avocados falling on the ground)
- ~10% rejections: Quality check for European standards
- Export
- ~5-6% loss: Avocados falling over, first layers of avocados sun-exposed
- ~1-5% loss: Overripe avocados, avocados losing weight

Source: Interviews

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

Enabling Trade: From Farm to Fork

January 2014
Hungry Planet: What the World Eats
Peter Menzel
Faith D’Alusio
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

Integrated causal loop diagram of the conventional European food system with indicated exemplar entry points for external drivers of change;

Environmental impacts of farming

Organic claims to be more environmentally friendly, Swedish Food Administration report shows it fails short in 39 out of 52 reviewed aspects. Conventional farming outperforms organic more often than the reverse.

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;

Seven Food System Metrics of Sustainable Nutrition Security Sustainability 2016, 8, 196;
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
Macroscopic technology will be built on platforms that collect and curate geospatial data so it can be easily searched.

- 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.
Kansas Study:

- 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

KS 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

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
  
  IoT²: 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, ...