

Agriculture Technologies & Transitions

**The Role and Trends of Agricultural Mechanization
on Commercial and Smallholder Farms**

Purdue University

John Lumkes

Brief Introductions

- Name
- Where are you from
- One goal you have for your time at Purdue
- Something interesting about you



africa agriculture business change climate
commitment community company completion contributing dedicated degree
development empowering energy engineering entrepreneur
entrepreneurship environmental experience farmers
farming fellows focusing food founder future gallery growth holds impact
industry innovation institute integrated international kenya leader
leadership leading management mandela market nutrition opportunities
organic passion photo plans produce production professional programs promoting purdue
research resources rural schedule science sector seed serves skills social solutions south
staff students sustainable tanzania technology training
university washington waste women worked years youth

Kick-off Exercise

- Break into groups of 4, ideally with someone who has a different interest area and from different location...
- Take 10 minutes and create a group vision for global and 'local' agriculture in 15 years.
 - Characteristics, technology, markets, etc.
- Report out to the group



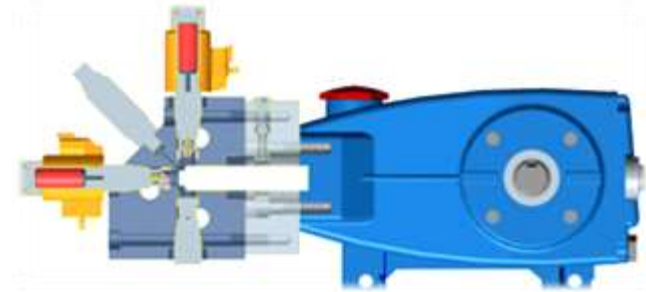
Humanity's Top Ten Problems (next 30 years)

- ENERGY
- WATER
- FOOD
- ENVIRONMENT
- POVERTY
- TERRORISM & WAR
- DISEASE
- EDUCATION
- DEMOCRACY
- POPULATION

Top 10 world problems and their solutions (2024)
Climate Change
Wars and military conflicts
Water contamination
Human rights violation
Global health issues
Global poverty
Children's poor access to healthcare, education and safety
Access to food and hunger
Migration
Weapons accessibility
Source: DevelopmentAid, January 11, 2024
https://www.developmentaid.org/news-stream/post/147458/top-10-world-problems-and-their-solutions

Research Activities

- Agricultural Mechanization for Smallholders
- Agricultural Robotics
- Fluid Power (digital hydraulics)
- Mechatronics



Power and Transportation for Smallholder Farmers

Impact farm mechanization, power for attachments, rural transportation, field work, and market access

- Cameroon (11 vehicles, 3 sold, multiple uses daily, partnership with NGO)
- Columbia (AgRover built at university, Farmer to farmer technical training)
- Guinea (AgRover fitted with rice harvester head, capacity building)
- Kenya (AgRover and 3 miniPUPs built at technical school for 8-17 yr olds, technical skills training)
- Nigeria (MAPS producing vehicles, 2 sold, for-profit joint venture)
- Uganda (2 AgRovers at Makerere University, partnership)

Activities demonstrated in the field: transportation, water pumping, maize grinding, threshing, rice harvesting, garbage collection, light tillage, and planting.

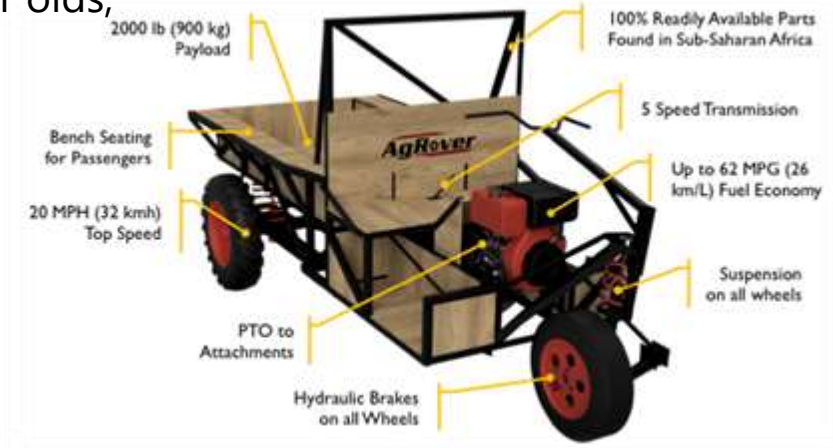
Development activities at Purdue: three-wheel personal-size tractor, electric driveline, remote monitoring and data collection system, maize grinder, light tillage attachments, no-till planter, electrical power generation, and welding.

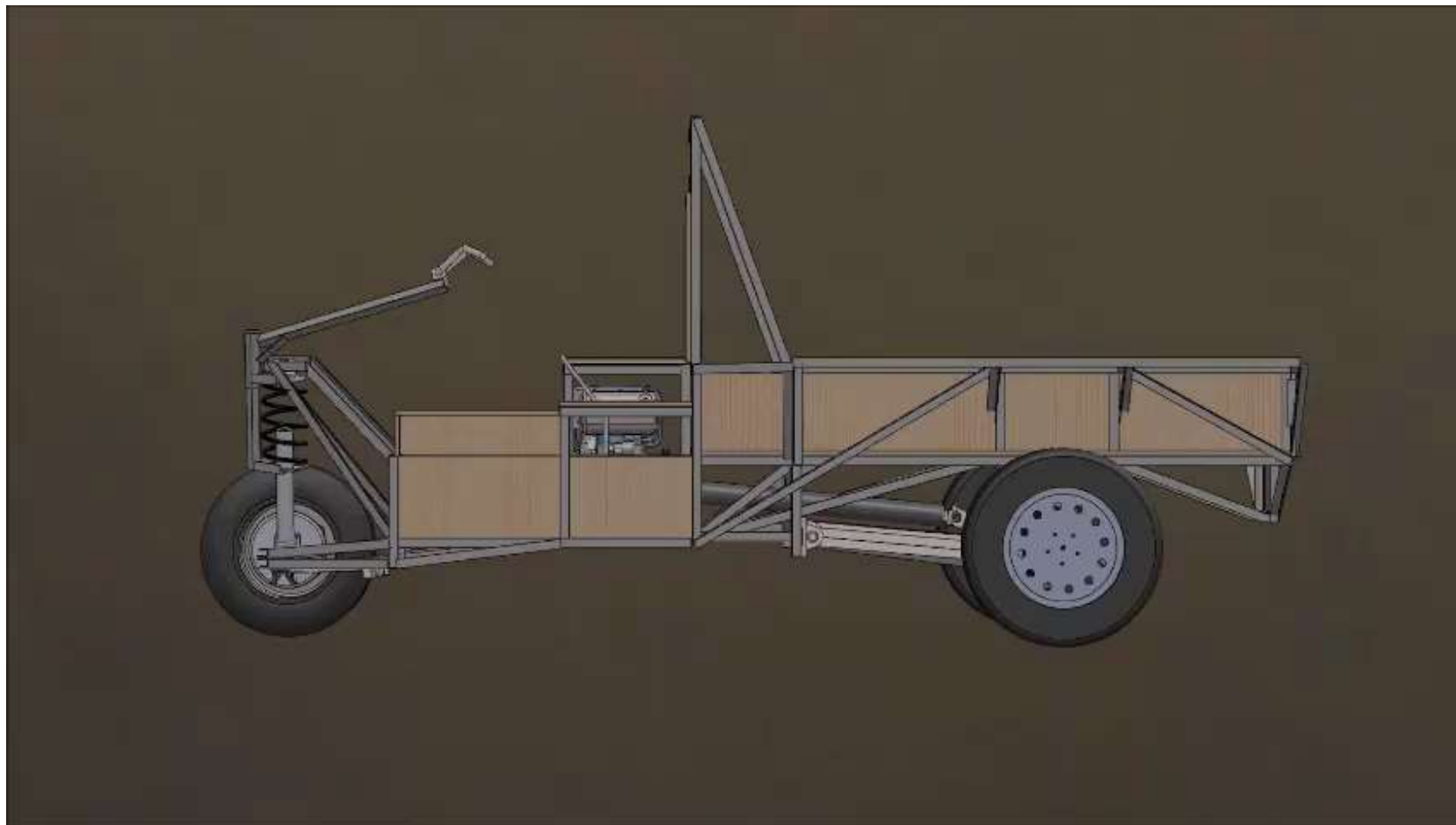
Purdue Utility Project
John Lumkes
(lumkes@purdue.edu)
engineering.purdue.edu/pup/

AgRover

MAPS
INTERNATIONAL

Lumkes, Purdue University





Attachments and Implements



Multigrain Thresher



Tillage and Planting



Water Pumping / Irrigation



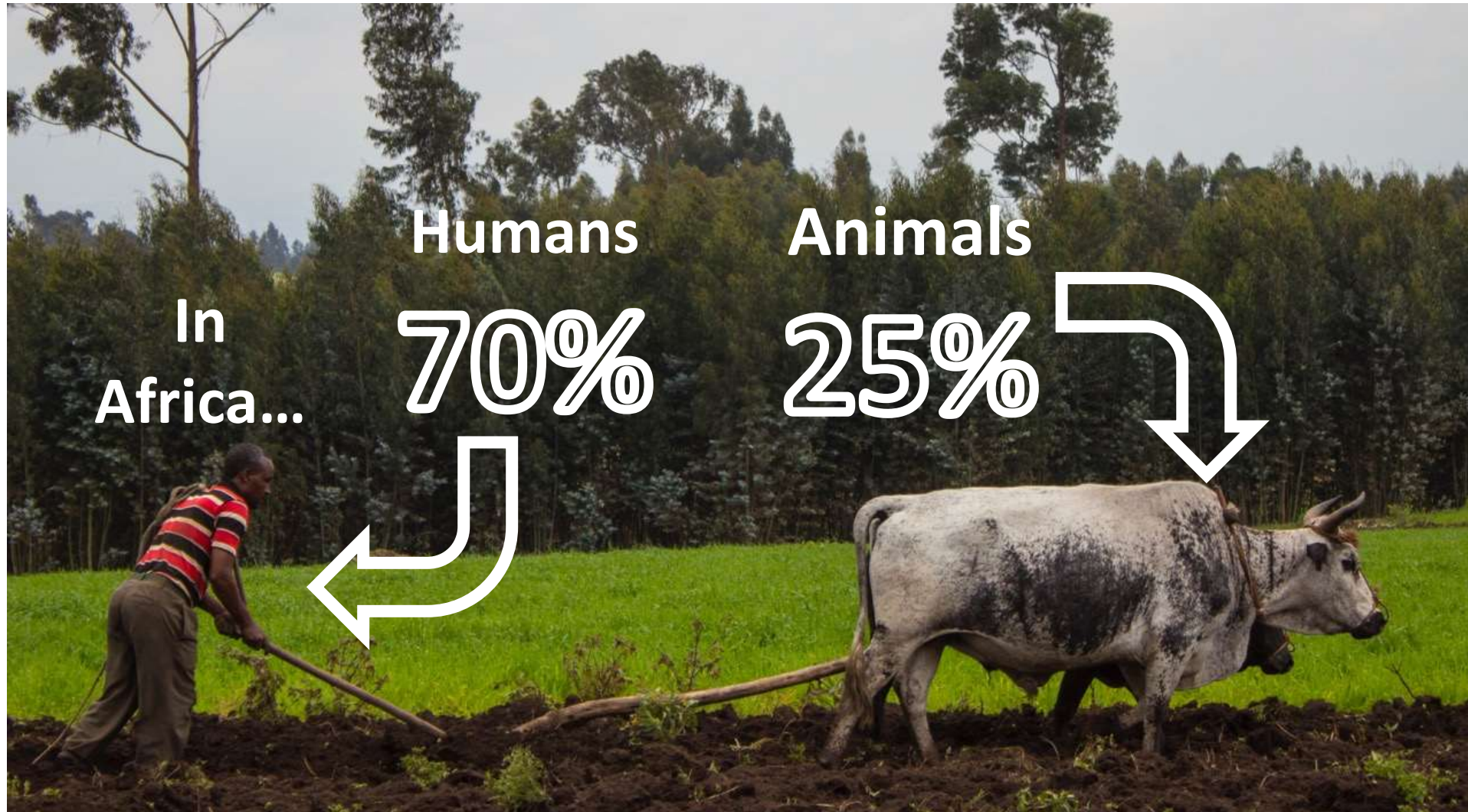
Food Processing / Maize Grinder



Challenge: Transportation



Challenge: Farm Power



Smallholder Farmer Challenges

- Gender Inequalities
- Food (Economic) Insecurity
- Subsistence Farming
- Inadequate Transportation
- Inadequate Access to Water
- Inadequate Agricultural Power
 - Inefficient harvesting/processing
 - Lack of refrigerated transport/storage
- Inadequate Access to Technology
- Unfavorable Policies/Governance
 - Venture capital is almost non-existent



Majority of small-holder farmers are women
And they provide 90% of the labor in processing food

~65% of Africa's labor force is employed
in agriculture, and ~32% of GDP

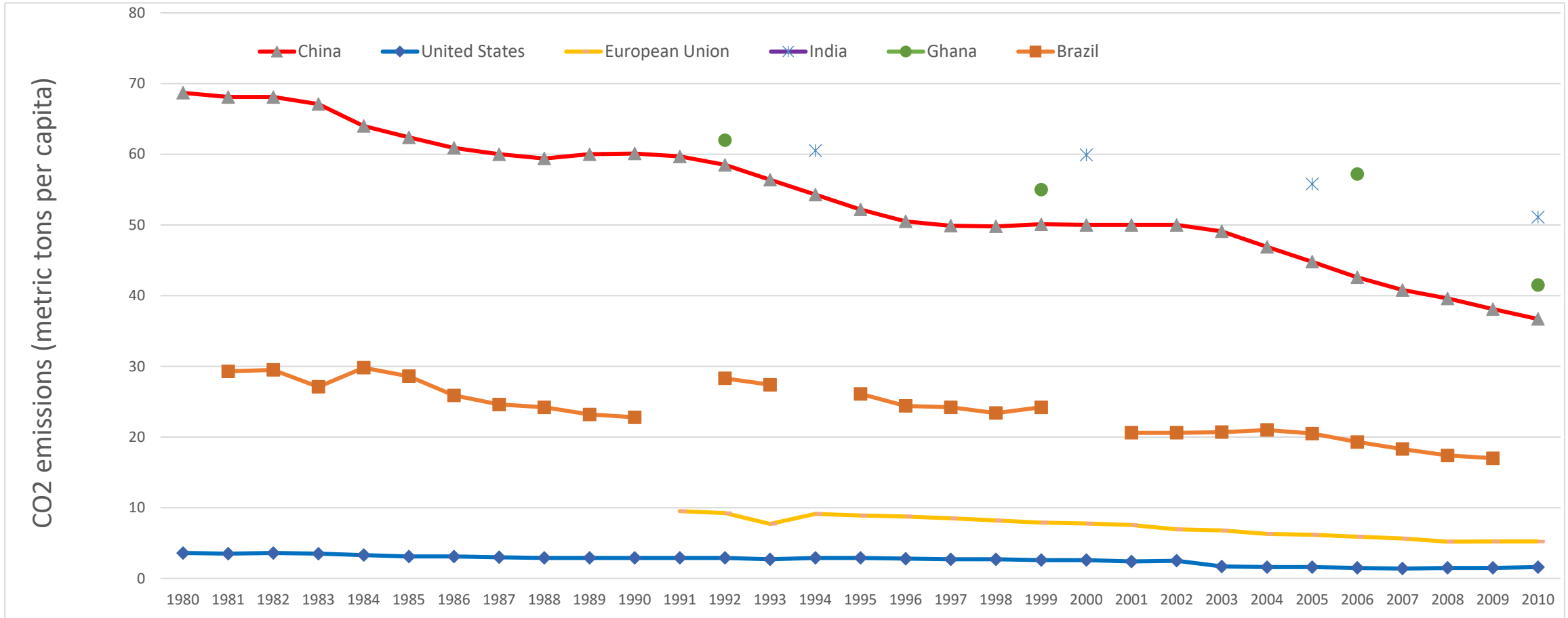
Average farm size is decreasing

Still have significant land that is not cultivated

Trends in United States Agriculture

- Farm and ranch families comprise just 2 percent of the U.S. population
 - 70-80% of the population in 1870's
 - 21 million American workers (15 percent of the total U.S. workforce) produce, process and sell the nation's food and fiber
- Farmers now produce 262 percent more food with 2 percent fewer inputs (labor, seeds, feed, fertilizer, etc.), compared with 1950
- In 2010, \$115 billion worth of American agricultural products were exported around the world
- One in three U.S. farm acres is planted for export
- Nearly 50 percent decline in erosion of cropland by wind and water since 1982.
- Last 30 years: Conservation tillage has grown from 17% to 63% (acreage)
- Last 30 years: Total land used for crops declined by 15% (70 million acres).
- Crop rotation is standard practice

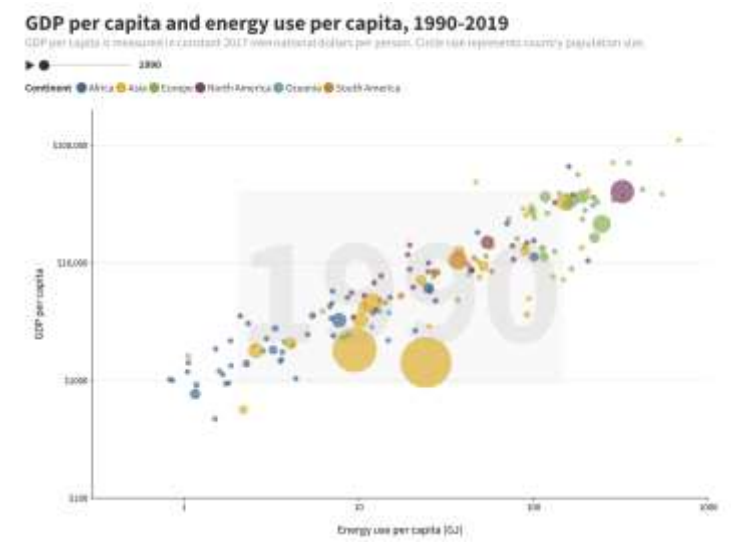
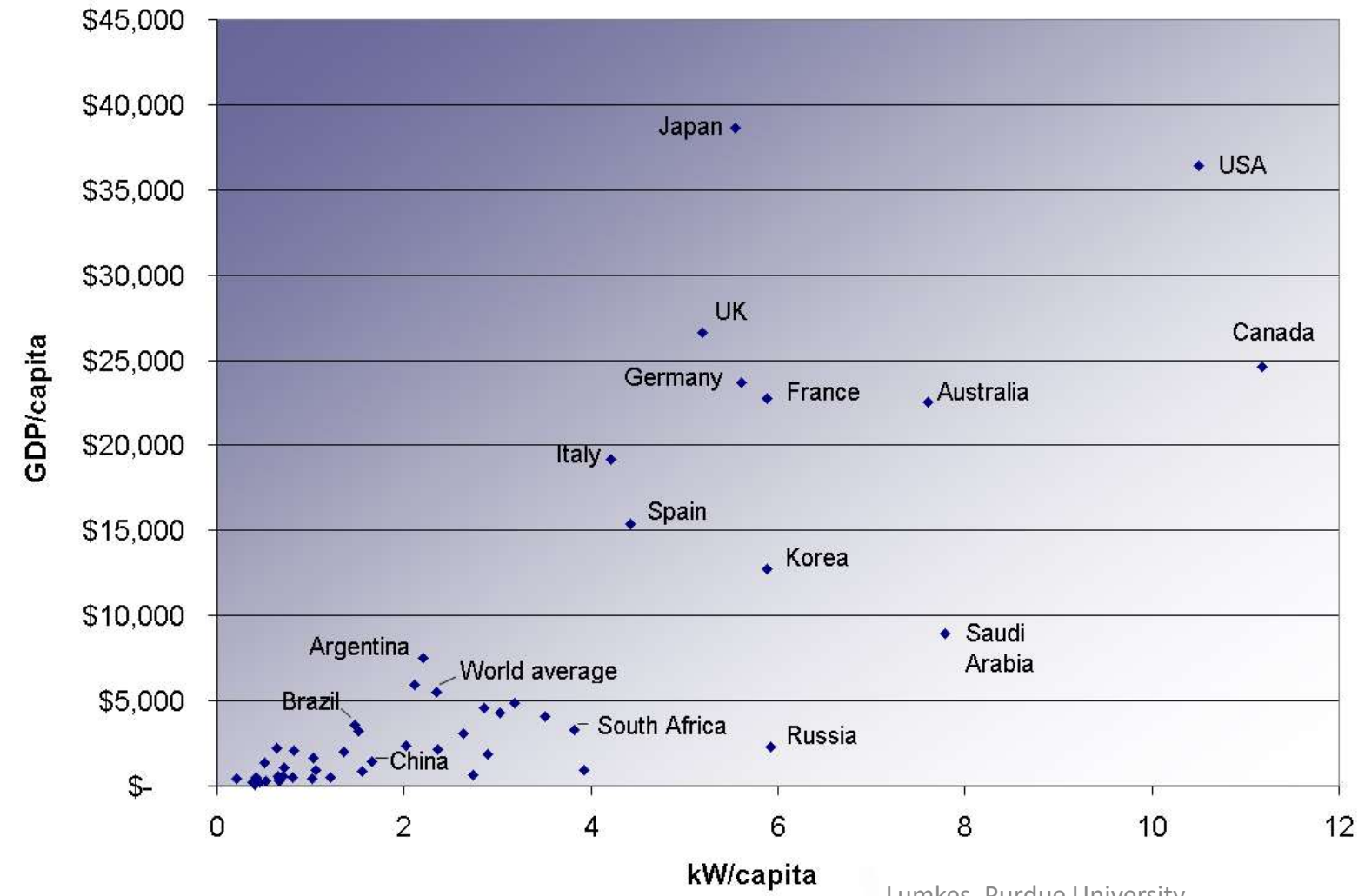
Agricultural Employment Trends



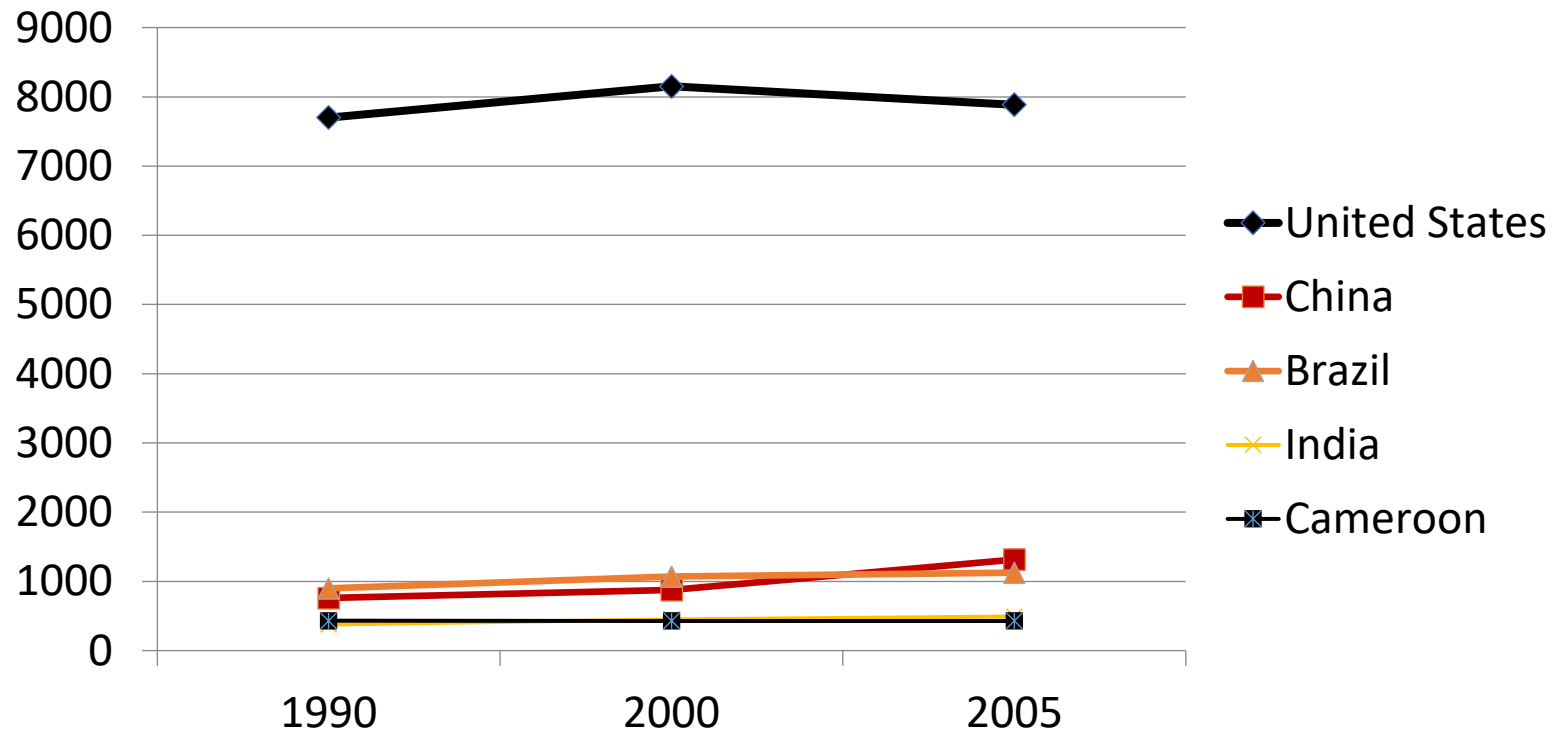
Energy Opportunities/Privileges...

- Energy (sources?)
 - Land preparation and maintenance, farm equipment, mechanization
 - Greenhouses
 - Water pumping, control of drip irrigation
 - Harvesting and processing
 - Transportation and drying
 - Refrigeration/storage, cooled field storage for fruits & vegetables to avoid field losses
 - Agricultural sensors (wireless) to monitor fertilizers & other inputs, traceability, GPS for precision agriculture
- Developing countries
 - 96 kg of oil equivalent/capita/ha (Kgoe) of arable land
- Industrialized countries
 - 312 kg of oil equivalent/capita/ha (Kgoe) of arable land

Energy consumption per capita versus the GDP per capita (2006)



Kilograms of oil equivalent (kgoe) per person

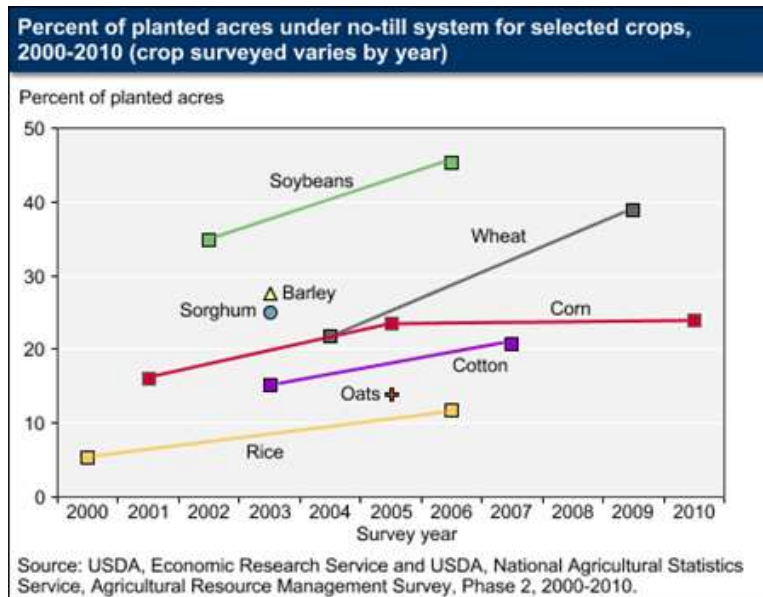


Where does agriculture fit?

- Agriculture Inputs
 - 70% of water used is in the global food value chain
 - And 30% of greenhouse gas emissions, 40% of employment
 - Mechanized agriculture is growing, but in the process has become dependent on fossil fuels
 - Fertilizers, Pesticides and Herbicides are increasingly dependent on fossil fuel
 - Nitrogen, the key to the first Green Revolution and the most important nutrient limiting yields, requires energy to produce urea using the Haber-Bosch conversion
 - Mechanization—tillage, cultivation, spraying, harvest, irrigation, drying grains, transport of goods, etc.
- Very few countries are able to achieve rapid economic growth apart from growth in agriculture
 - Michael Lipton, economist at University Sussex “No country has achieved mass poverty reduction without prior investment in agriculture”
- ~400-500million farms (<2ha), about 1/3 of the worlds population are dependent on these farms

Trends in United States Agriculture

- No Till / Strip Till (Conservation Agriculture)
 - Approximately 65% of soybean and 25% of corn acres
 - 35% of all cropland, increasing 1.5%/yr
 - Correlation with fuel prices



Soybeans grown into corn stalks in a no-till field in Union County, Iowa (USDA)

Trends in United States Agriculture

- Cover crops
 - Aerial seeding on standing corn and beans (\$30/acre total)
 - Rye grass, clover, winter peas, radishes, turnip, etc.
 - Reduces erosion and fertilizer runoff
 - The root base breaks up hard packed soil, adds organic material to soil, attracts earthworms, etc.
 - Less nitrogen is needed (especially if legumes are used)
- Iowa went from 10,000 acres in 2009 to 300,000 acres in 2013



<http://ryegrasscovercropblog.com>

Trends in United States Agriculture

- Precision Agriculture

- RTK GPS provides centimeters of accuracy
- Started with auto-steer, moving to autonomous, and planning for site-specific delivery of all inputs
 - Goal: place what is needed, when it is needed, where it is needed...
100 millions tons of Nitrogen was produced in 2005
but only 17% was taken up by crops
(Conway, 2012)



- Big Data

- Everything has sensors, collects data, now what?



John Deere Machine Sync, deere.com

Trends in United States Agriculture

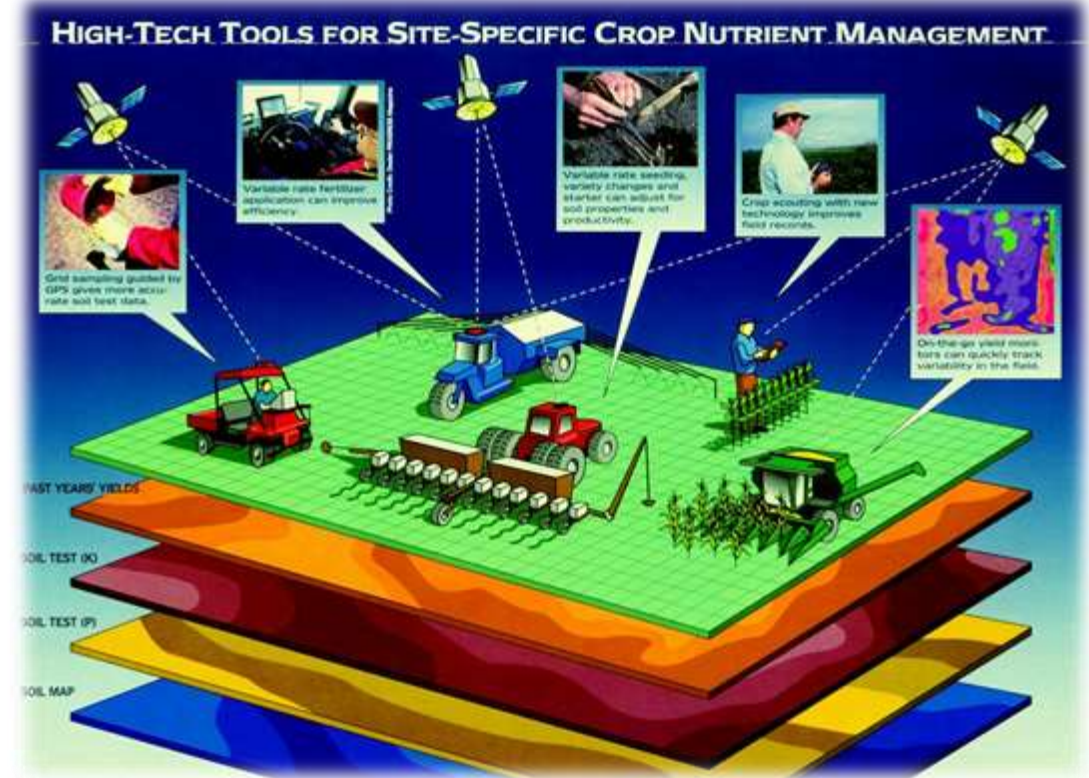
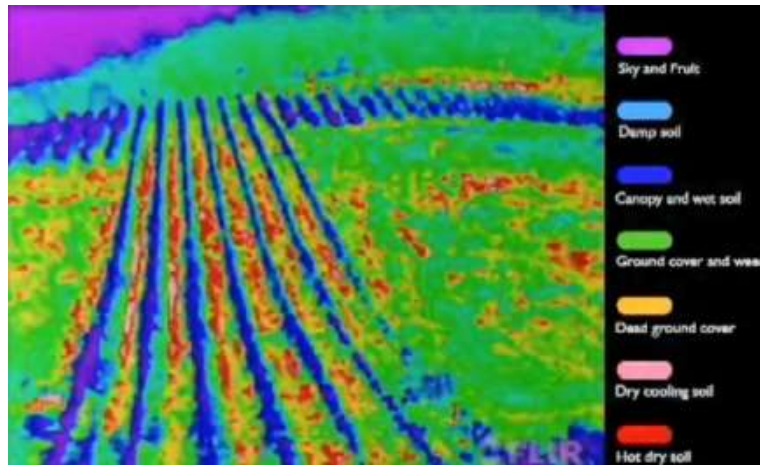
- Big Data
 - Everything has sensors, collects data, now what?



farmprogress.com



headwallphotonics.com



Trends in United States Agriculture

- Robotics

- Assistive robotics / labor shortages

- Some industries rely on migratory workers (harvest time)
 - Already: milking cows, cleaning and sorting eggs, semi-autonomous tractors, combines, etc.
 - Research: selectively harvesting fruits and vegetables, food processing (deboning chickens), weeding, etc.



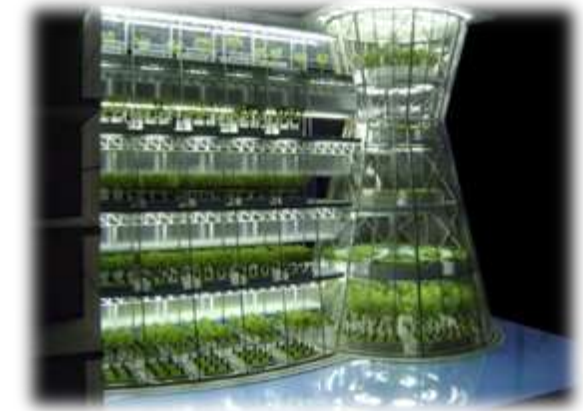
Orange harvester. Photo credit: Vision Robotics Corporation. Lumkes, Purdue University



DeLaval Milking Station. via [Wikimedia Commons](#).

Urban agriculture/vertical farms

- More Automation and Technology
- Sensors/IOT/Robotics
- LED lighting, energy constraints
- Hydroponics, Controlled Environments
 - Converting city buildings



ecofriend.com/urban-farming-food-insecurity.html



We Need a Globally Inclusive Paradigm Shift

Enabling the Doubly Green Revolution

What are the enablers?

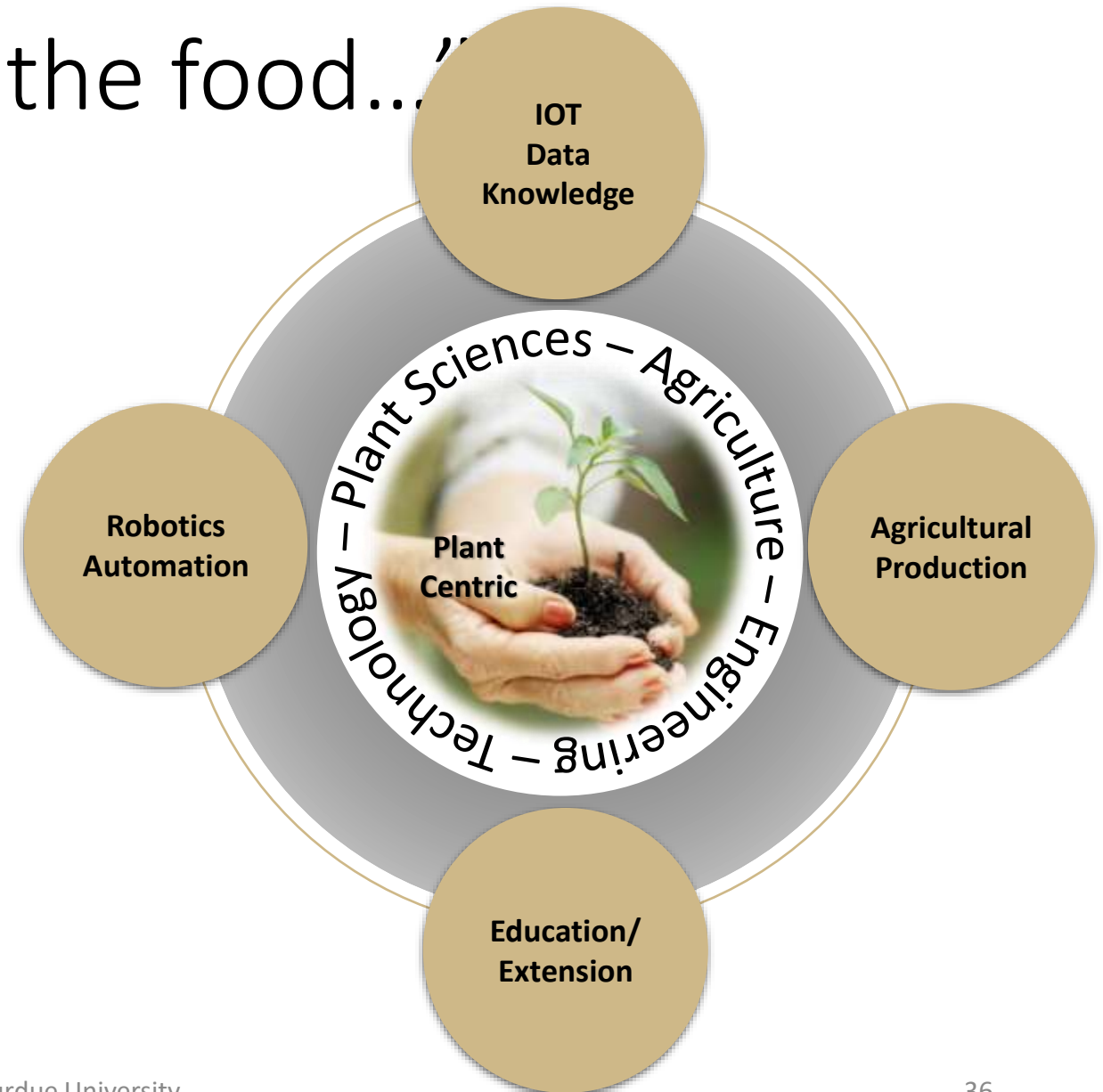
- How does nature optimize production?



- Can we develop data-driven systems that enable plant-by-plant care?
- Will it be globally effective?

“Connecting the data to the food...”

- Agriculture robotics/automation
- Energy impact of agricultural automation (**Electrification**)
- Smart actuators and machines
- Mechatronic systems for agriculture
 - IOT
 - Data Science
 - Crop Technology



Conclusions

- Poverty is a major cause of hunger (just growing more food will not solve this)
 - On average, enough food is already produced
 - But are we currently sustainable?
 - Reducing post-harvest losses in some areas is crucial
- We need to holistically manage our natural resources
 - Technology can help, but only one piece of the puzzle
 - Research is needed on biotechnology, farming techniques like CA, growing more with less water, improving our soils over the long term, etc.
- Government policies are critical

Questions / Discussion



John Lumkes
Agricultural & Biological Engineering